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WHETHER FOR STEAM... or...

[Please turn overleaf

Hydro-electric pipe-line in course of installation

...FOR HYDRO-ELECTRIC POWER,

the steel pipes are

S&L

STEWARTS AND LLOYDS, LIMITED · GLASGOW · BIRMINGHAM · LONDON

A Seven-Day Journal

Fuel for Portable Gas Producers

AT the beginning of September the British Coal Utilisation Research Association began a comprehensive study of producer gas and during the past six months has added very considerably to the knowledge on this subject. At an early stage it became obvious that the quality of fuel used would have to be very carefully controlled, and after consulting with the plant manufacturers, the Producer Gas Fuels Committee of the Coal and Carbonisation Industries issued the Specification No. 1 for Transport Producer Gas Fuels. The specification is being considered by a British Standards Institution Committee representative of the motor trade, the Operators' Associations, fuel interests, plant manufacturers and others with a view to its issue as a British Standard. Meanwhile the Producer Gas Fuels Committee has asked the British Coal Utilisation Research Association to investigate the factors involved in the national distribution of Producer Gas Fuel, and the Association is seeking the help of the garages and commercial vehicle users in order to find precisely what the requirements are likely to be. There is no existing sales machinery which can be used for the retail distribution of producer gas fuel at the roadside, and a method which it is said may well be adopted is to arrange for the fuel to be available at key points throughout the country, using for this purpose garages and motor engineers who specialise in catering for the needs of commercial vehicles. Several such firms are already interested in producer gas and have expressed a wish to stock the fuel. It is not intended, however, to distribute producer gas fuel through every garage and service station which now stocks petrol. One of the main objects of any scheme which may be put forward will be to keep the price of fuel down to the lowest possble figure. No retail price has yet been decided, but the indications are that it will be about £6 per ton for normal fuels, with an extra charge of about 7s. 6d. for those which come under the category of "specially dried," independent of the distance from the colliery or carbonisation plant. In order to ascertain road operators' views on producer gas fuel, the Association has drawn up a questionnaire which is about to be issued through Associated Road Operators and other trade organisations.

The Late Sir George Buchanan

WITH the death of Sir George Cunningham Buchanan at the age of 74 on Sunday, April 14th, the consulting engineering profession of this country has lost a prominent figure. He received his early training as a civil engineer on the harbour and dock works on the River Tyne, and during his career was associated with a large number of outstanding river, dock, and harbour projects in this country and abroad. In 1901, after having served as engineer-in-chief to the Dundee Harbour Trust for five years, he went to Rangoon where he was appointed chairman and chief engineer of the Port Trust. During the fifteen years he served at Rangoon he was responsible for the entire reorganisation of the port and carried out the river draining works, these works involving a cost of over one million pounds. In 1915, after being knighted, Sir George left Rangoon and went to Basra with the Mesopotamian Expeditionary Force. Whilst there, he designed the new port of Basra and carried out improvement schemes on the Rivers Tigris and Euphrates. For this work he was made a K.C.I.E. and held the rank of Brigadier-General, it being stated by the Government of India that his valuable services had sensibly promoted the success of our arms in Mesopotamia. He afterwards became consulting engineer to the Back Bay Reclamation Scheme at Bombay. In 1922, at the request of the Government of South Africa he visited that country to examine and report on the transport facilities particularly in connection with the ports and harbours. Upon completion of this work he went to Australia in 1925 and made an examination of the transport facilities for the Government and prepared a report on the administration and development of Northern Australia. He was the author of several books, one of the best known of which was "The Tragedy of Mesopotamia" in which he described much of his work in that country during the war.

Refuelling in Flight

ON Friday last, April 12th, Sir Alan Cobham and Mr. Marcus Langley read a paper before the Royal Aeronautical Society entitled "The History and Progress of Refuelling in Flight." The meeting and subsequent discussion were held under the chairmanship of Lieut.-Colonel J. T. C. Moore-Brabazon at the Institution of Electrical Engineers. Based mainly on previously published reports, the paper outlined the progress of refuelling in flight as devised by Flight Refuelling, Ltd., and dealt with the possibilities of its application for long-range aircraft. Our readers will recall that a report was published in THE ENGINEER last week on the subject, and in our issue of August 4th, 1939, a description of a visit to the company's aerodrome and of the equipment in use was given. The discussion that followed the paper elicited several interesting points. One speaker stated that up to the present normal aircraft had been converted for refuelling in flight. But there was the question whether there would in future be designed a machine which would not require refuelling. He submitted that that view was wrong, and that refuelling was not an interim measure. For long-range flights the question was whether to use a limited number of large aircraft or a greater number of smaller aircraft. In reply, Mr. Langley said that he would like to see aircraft specially designed for refuelling in flight, and suggested that there was no need for very large aeroplanes and flying-boats weighing 100 tons and more. It would be better to have smaller planes refuelled and giving a more frequent service. Several speakers stressed the necessity for efficient means of jettisoning fuel and to them Sir Alan Cobham replied that in designing jettisoning equipment there was no mechanical difficulty but that the fuel must be discharged outside the disturbed air surrounding the aircraft. Other speakers referred to the military aspect of refuelling in flight. The advantages to be gained were obvious, but amongst those that might be overlooked were that obsolescent machines could be used efficiently as refuelling tankers and that, should a very long range be not required, refuelling could possibly be used as a means of increasing the machine's cruising speed, for with extra fuel the heavier fuel consumption as a result of increased speed could be tolerated.

French Armament Factories

IN a statement made in Paris at the end of last week Mr. MacLaren, Director-General of Ordnance attached to the Ministry of Supply, expressed admiration for all that he had seen during visits to a number of French armament factores in various parts of the country, and said that on his return to this country he intended to send out a number of his senior specialist officers to France with the intention that they should take note of a number of matters on which French practice might usefully be studied. Mr. MacLaren was particularly impressed by the intensity with which work is proceeding in French factories and by the large part women are playing in these factories. He found it amazing to see women doing work which would normally be reserved for highly skilled men, and he expressed admiration for the helpful attitude of the male workers towards the women. Reference is made in our French Engineering Notes on another page of this issue to the scheme that is now in operation for ensuring the training of boys and women in French works. Mr. MacLaren declared that this scheme was giving astonishing results. He witnessed work being done by boys and women which looked as if it had been done by workmen with several years of training. The conclusion to be reached was that not only the methods employed were excellent, but that the quality of the workers, their intelligence and grit was very high. He also mentioned that research was going on for methods of utilising substitute materials for copper and steel, and also expressed himself impressed by the ingenious adaptation of machinery to special uses pending the arrival of machines specially built for those purposes.

Structural Steel in Buildings

STEEL framed structures of the type commonly used for office buildings and warehouses consist chiefly of horizontal beams and vertical stanchions. They are usually designed by a procedure which disregards the effect of the connections of the beams to the stanchions; the beams are designed as if they were freely supported and the stanchions without regard to the bending applied by the beam. The procedure has the merit of simplicity, and long experience has proved that it does not introduce significant weakness into the structure. It is, however, thought to be uneconomical because it results in the beams being designed for bending moments which are undoubtedly in excess of the true values. During the years 1929–36, the Steel Structures Research Committee appointed by the Department of Scientific and Industrial Research undertook a more accurate investigation of the stresses in steel framed structures and recommended a method of stress calculation and design procedure of a much more laborious kind. A joint Committee of the Institution of Civil Engineers and the Institution of Structural Engineers has investigated the Steel Structures Research Committee's method of design and has found that it produces no marked economy if the material is stressed to the values recommended by the Research Committee. The joint committee of the two Institutions has now issued a code of practice which helps to clarify the position. Following laborious calculations conducted for it by Professor J. F. Baker, the joint committee recommends that subject to certain requirements being fulfilled a beam attached at both ends to stanchions shall be designed to withstand a bending moment equal to eight-ninths of the maximum moment calculated on the assumption that it is freely supported. If the beam is secured to a stanchion at one end and freely supported at the other it shall be designed to support seventeen-eighteenths of the maximum moment calculated on the assumption that it is freely supported at both ends. The stanchions are to be designed in accordance with existing rules. The requirements to be fulfilled relate to the design of the connection between the beams and the stanchions. It is also laid down that the ratio of the stiffness of the beam to the stiffness of the stanchion shall not exceed a certain stated limit.

Scotland and the Export Drive

THE President of the Board of Trade, Sir Andrew Duncan, recently visited Glasgow where he interviewed a large number of exporters and industrial representatives with regard to the Government's effort to increase exports. At a luncheon given by the Glasgow Chamber of Commerce he said that he hoped that Scotland's participation in the effort would bring her proportion of total exports to an even higher percentage of the national total than at present. After describing the objects and working of the Export Council, Sir Andrew said the policy adopted had already met with a very prompt response from within industry itself and already more than thirty Export Groups had been formed. In dealing with the export of iron and steel he said that in spite of the armament demands the Board of Trade had been able to arrange for definite allocations of steel for foreign orders. Some of the Export Groups had already estimated their requirements and had been granted the steel supplies without which they could not have confidence in seeking and booking orders from abroad. Considerable progress had also been made in the allocation of non-ferrous metals for overseas and the Export Groups were in close contact with the appropriate authority. He then turned to the subject of coal exports and stressed the importance of expanding that branch of trade abroad. In describing it as the foundation of Scotland's industrial expansion he said that there was an abundant export demand for coal. In view of this fact increased production became a national necessity and the Export Council looked with confidence to the contribution which the industry would make. Sir Andrew hoped that the Production Council set up under Lord Portal would be fruitful, with speedy results, with the full co-operation of the federations of both coal owners and men.

The Late Mr. P. F. Russell

ALL members of the electrical profession in this country, and many in France, will hear with sincere regret of the sudden death of Mr. Percy Fitz-Patrick Rowell, the former Secretary to the Institution of Electrical Engineers, which occurred on Monday, April 15th. He was born in London in September, 1874, and received his early training at the Royal College of Mauritius, where he was awarded the Gold Medal for Mathematics and Leaving Scholarship in 1893. Later he went to King's College, London. After a short time in the service of the British Thomson-Houston Company he joined the staff of the Institution of Electrical Engineers in 1901. He became assistant secretary in 1904, and was appointed Secretary in 1909. He retired from that office in May, 1939, and it is regrettable that he only enjoyed his rest from a very active career for less than a year. Mr. Rowell was not an engineer, but his outstanding abilities as an organiser and an administrator particularly fitted him for such a responsible post in one of this country's leading technical institutions. His influence upon the activities of the Institution is probably best indicated by the fact that when he joined it thirty-nine years ago the membership was just over 4000, and to-day it is in the region of 20,000. He was an excellent French linguist and did much to promote the exchange of electrical knowledge between this country and France. Many members of the Institution look back with great pleasure to the number of interesting and enjoyable visits to France which he organised. In these trips to France visits were made to a number of prominent electrical works and installations and they also included a number of delightful social functions. For his work in this direction Mr. Rowell was made an Officier de la Legion d'Honneur and a Membre d'Honneur de la Société Francaise des Electriciens.

Turbine Locomotive Experiences

By EDWARD H. LIVESAY

No. I

Introduction

THE turbine is a very fascinating prime mover, with which the inventive minds of engineers have been concerned for a longer period than is sometimes realised. As a matter of fact, I believe, for about 2000 years! Was not Hero of Alexandria the first to discover that a jet of steam, when directed against vanes attached to a spindle, caused vanes and spindle to revolve? By so doing, he had hit upon the basic principle which, when applied in various ways—to windmill, water-wheel, and finally steam turbine—has come down through the centuries, at long last to become concrete in the shape of the turbine locomotive "No. 6202." So it would appear that the family tree of this particularly interesting engine is more impressive than that of any other locomotive whatsoever, and the diffidence with which I begin this account of its working, as noted by myself, is correspondingly great. In recent issues of THE ENGINEER I have tried to describe the work of a good many striking engines, but I think it will be agreed that this particular machine is quite out of the ordinary, and stands in a class by itself. It is certainly very different from any other that I have previously dealt with, and for that reason I may fail to do justice to it. I approach this article with much the same uncertainty that disturbed the Ancient Mariner, when he reflected that he was "the first to break into that silent sea." I felt this, too, when I entered the cab of "No. 6202." Things in it looked strange to me; I did not know what I was going to experience, and the cab did actually turn out to be very much a "silent sea"—there were few of the familiar sounds one hears on the footplate of the usual type of locomotive. Like an explorer threading a jungle, I was not sure what was going to happen, and I am still not quite certain what may be the result of this descriptive effort.

There is something very attractive in the conception of a turbine locomotive. A modern engine is, of course, a thoroughly practical machine, but it is somewhat like a horse, which, though undoubtedly a noble animal, "does not always do so." Its reciprocating machinery, and complicated valve-gear need a good deal of attention, and it is apt to be somewhat hard on itself and on the track. The turbine, on the other hand, gets rid of these disturbing factors, and, in theory at any rate, should need less care and adjustment. Its primary driving mechanism is the acme of simplicity, and has a silky-smooth action that not only should reduce slipping to vanishing point, but in addition banishes unbalanced forces, with their resulting hammer-blow. The advantages in theory are obvious, but the drawbacks that are sure to arise in practice can only be discovered by the actual construction and operation of a locomotive utilising this singularly alluring method of propulsion. For this reason, all credit is due to those engineers who have attacked the problem in a practical way, by actually building locomotives with turbine drive. The cost of these experimental machines is naturally great, and it is probably this stern deterrent that has hitherto given pause to many engineers who would have liked to test their ideas in practice, and explains why it is only in comparatively recent years that serious attempts have been made to adapt the turbine to locomotive purposes. A brief history of the chief attempts may be of interest, showing some of the previous steps that have prepared the way leading to the construction of "No. 6202."

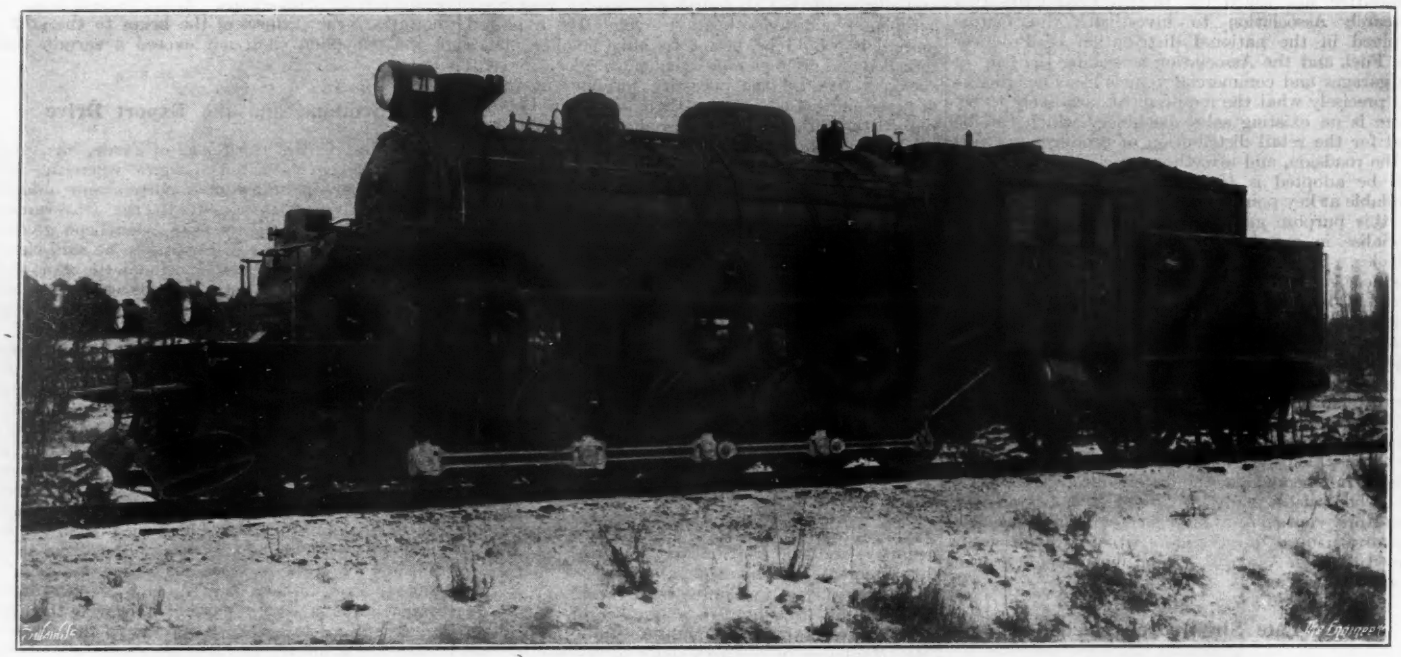

FIG. 1—LJUNGSTROM TURBINE LOCOMOTIVE

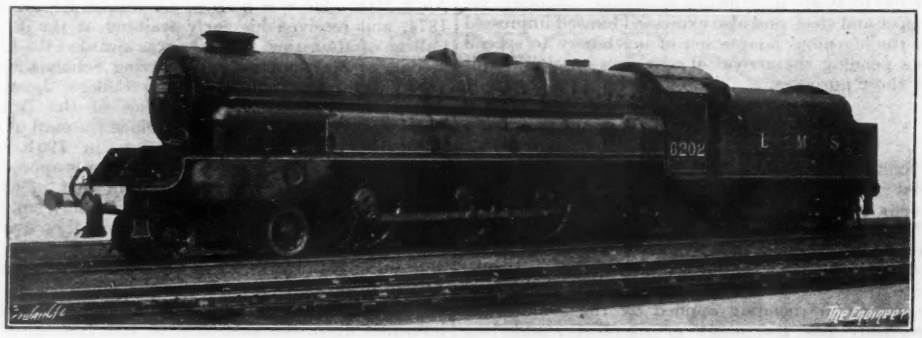

FIG. 2—L.M.S.R. "TURBOMOTIVE" NO. "6202"

Historical Review

Disregarding turbo-electric systems, which do not come within the scope of this brief review, I believe that it was not until 1920 that the turbine was first employed to drive a locomotive direct, without the interposition of electrical transmission. This was on the Reid-Macleod[1] condensing engine, a most promising machine, which deserved a better fate than has apparently befallen it. It was built on the unit plan, running on two groups of four axles, placed at the extremities of the single frame. Each group formed a compound bogie, with two driving axles and a guiding bogie at either end. A high pressure turbine was mounted on the rear group, driving the axles through gearing, and a low-pressure turbine was placed on the front group. There were no coupling rods, and condensing apparatus was used, the whole machine being neat in plan, and of exceptionally good appearance. It did some experimental running in Scotland, but if it still exists, nothing has been heard of it for several years. Theory and practice evidently could not agree—in some respect or other theory was evidently at fault.

Then, in 1921, came the Zoelly[2] condensing engine, a standard 2–6–0 locomotive experimentally adapted to take a turbine, which was placed in front, driving the coupled wheels by side-rods from a jack-shaft. I have no knowledge of its subsequent history, but it, too, does not seem to have set the Thames on fire. The Maffei Company in Germany also experimented with turbine engines.

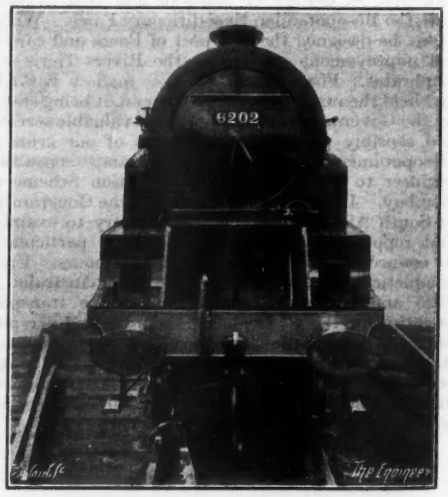

FIG. 3—FRONT VIEW OF "TURBOMOTIVE"

The next example to be mentioned is of greater importance, as it led directly to "No. 6202"—the Ljungström,[3] which made its appearance in

1921. The first type consisted of two units, the leading one running on five axles, two of which constituted a guiding bogie, the other three being merely for carrying purposes. This formed the boiler unit, the coal bunker being arranged over the firebox. The steam pressure was 285 lb. per square inch. The second unit formed the driving plant, and ran on six coupled wheels, with a trailing bogie truck. The single turbine drove a jack-shaft through gearing, and thence by side-rods the first coupled axle, and was of 1800 H.P. Reversing was carried out by the interposition of an idler pinion in the gear-train. The air-cooled condenser was also mounted on this power unit.

This engine was quite successful, and several

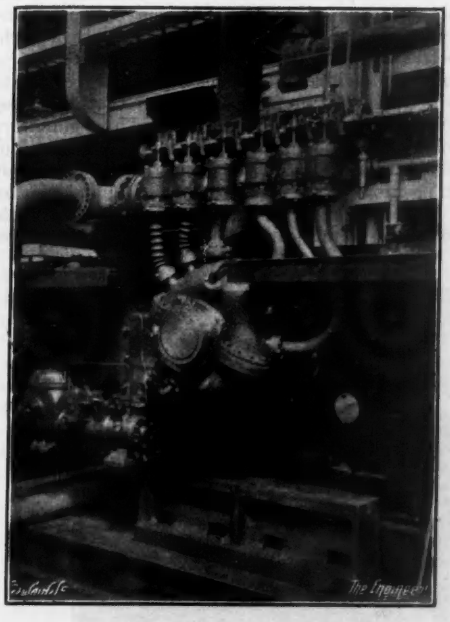

FIG. 4—AHEAD TURBINE

others were subsequently built to a similar design. Messrs. Beyer-Peacock obtained the licence to construct engines on this system, and in 1926 one was built with the same lay-out, working on the L.M.S.R. between London and Manchester for some time.[4]

The latest design of Ljungström engine is shown in Fig. 1, and it was after investigation into the working of this type that Mr. W. A. Stanier designed "No. 6202." The Swedish engine has the 2–8–0 wheel formation, a non-condensing turbine being placed in front of the smoke-box, driving a jack-shaft through gearing, and thence by side-rods the coupled wheels. As in the earlier design, reversing is brought about by means of an idler-wheel interposed between two disengaged wheels in the gear box. The turbine is of 1370 H.P., with a maximum of 2000 H.P., and the boiler is pressed to 185 lb. per square inch. Trains of 1700 tons were hauled on test runs up gradients of 1 in 100, the drawbar pull being 21·6 tons. Though the factor of adhesion was only 3·3, the continuous even torque of the turbine resulted in a complete absence of slipping, and there was an appreciable saving of both fuel and water. The test results were sufficiently satisfactory to warrant the building by the L.M.S.R. of an experimental

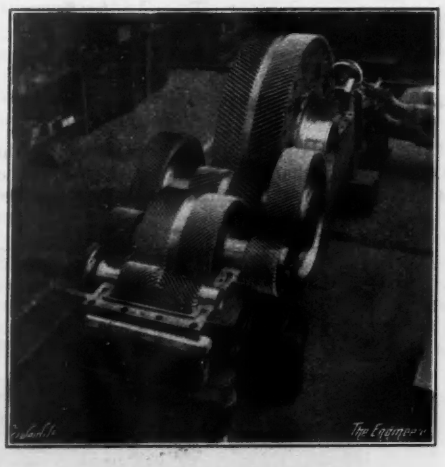

FIG. 5—REDUCTION GEARING

engine of improved design, and "No. 6202" was the outcome. Among the advantages that it was hoped would be found were lower fuel and water consumption, increased drawbar pull at high speeds, reduced maintenance cost, greater availability, and absence of hammer-blow.

L.M.S. "No. 6202"

The outward appearance of "No. 6202" is shown by Figs. 2 and 3, and I think it will be conceded that it is easily the best-looking turbine locomotive that has so far appeared. It is, I believe, an architectural axiom that "what looks right is right," and if one applies the same maxim to locomotives, there should be very little to complain of in "No. 6202." There is nothing about it to offend the most aesthetic critic, which is more than can be said of some of its predecessors! The mechanical arrangement of this engine differs in several important respects from any of its progenitors. The design is based on that of the "Princess Royal" class of engine, the running gear, wheel-base, boiler, &c., being similar. The Metropolitan-Vickers Company of Manchester was responsible for the construction of the turbines and gearing, and for their fitting up, the chassis being sent to their works for this to be done. There are two turbines, placed outside the main frames, between the bogie wheels, in the position usually occupied by the outside cylinders of a

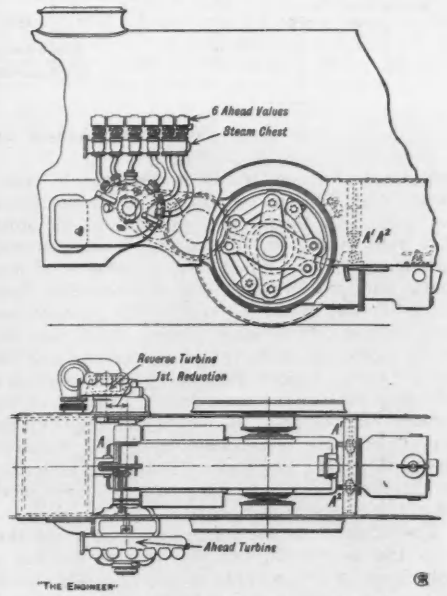

FIG. 6—ARRANGEMENT OF TURBINE DRIVES

reciprocating engine. The main, ahead multi-stage turbine (Fig. 4) is on the left side, and the reverse impulse turbine on the right. The former drives the first coupled axle through treble reduction gearing (Fig. 5), and the latter through quadruple, the same train of wheels being used by both turbines, with the exception that an additional wheel, giving the fourth step down, forms part of the reverse turbine's gear-train (Fig. 6). All the shafts are transverse, and lie between the side

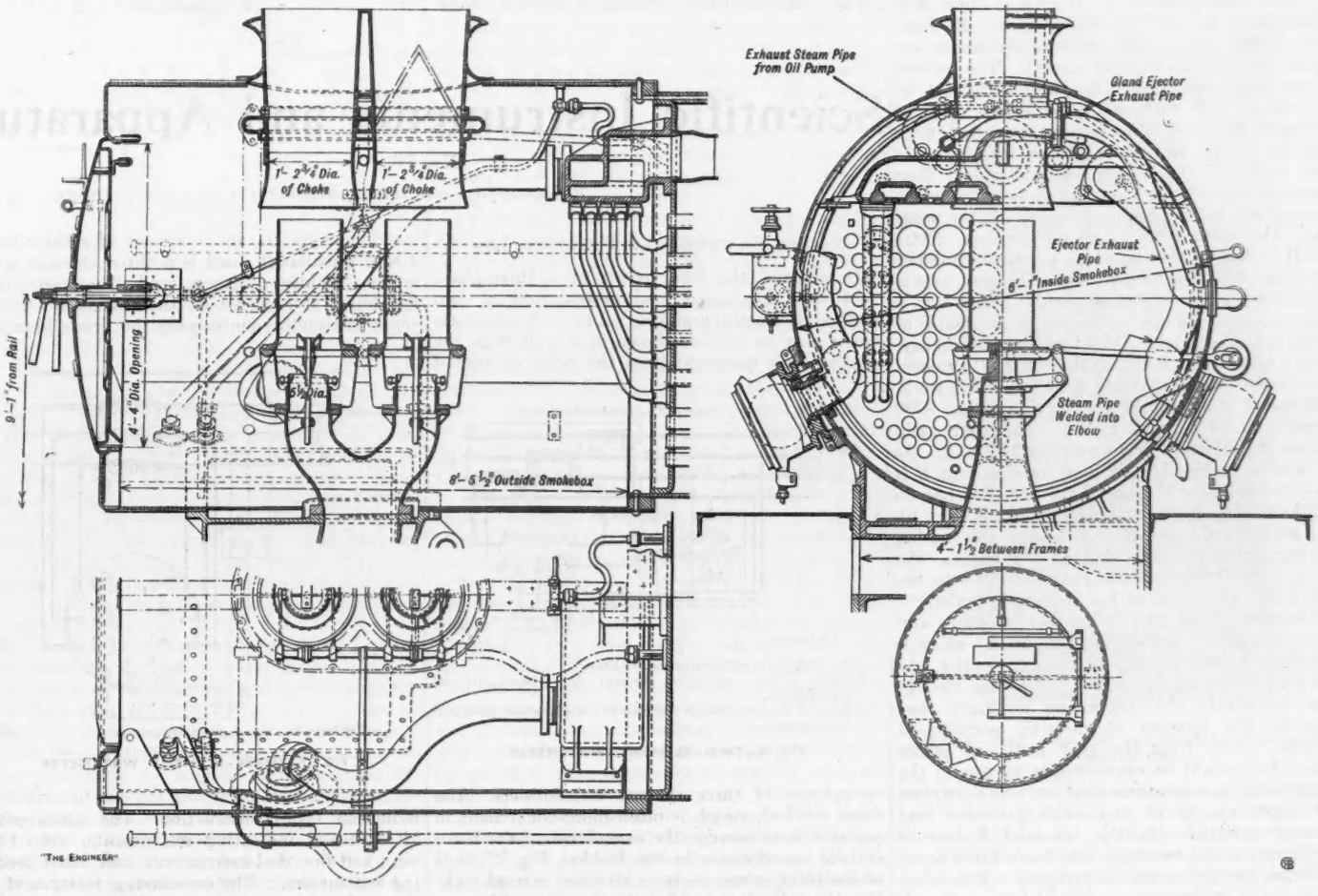
Exhaust Steam Pipe from Oil Pump
Gland Ejector Exhaust Pipe
1'- 2¾" Dia. of Choke
1'- 2¾" Dia. of Choke
Ejector Exhaust Pipe
6'- 1" Inside Smokebox
9'- 1" from Rail
4'- 4" Dia. Opening
6'- 5½" Dia.
Steam Pipe Welded into Elbow
8'- 5½" Outside Smokebox
4'- 1½" Between Frames
"THE ENGINEER"

FIG. 7—ARRANGEMENT OF SMOKE-BOX

frames, beneath the boiler. Flexibility is allowed for by quill couplings at two points between the main turbine and the driving axle, one of which is shown in Fig. 6. All the gear wheels and bearings are enclosed in a case, and are lubricated mechanically from a well at the rear, in which a submerged gear-pump is placed, forcing the oil at 25 lb. Incidentally, the first and third driving axles carry over 23 tons each, a greater load than is found on any other British locomotive, the absence of hammer-blow making this unobjectionable (Fig. 8).

The boiler, working at 250 lb., is similar to the "Princess Royal" pattern, and is 5ft. 8§in. in diameter at the smoke box, increasing to 6ft. 3in.

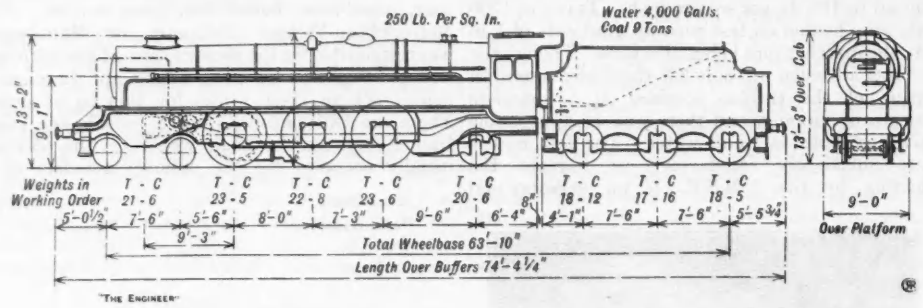

FIG. 8—DIAGRAM OF THE "TURBOMOTIVE"

pressure to various points in the case in spray form, and to the shafts. The transmission gear-case has three-point suspension, in order that any flexing of the engine frames should not affect it, nor upset the alignment of the shafts and gear wheels. Fig. 6 shows the three points of support, A, A^1, and A^2, the forward one being ahead of the main turbine shaft, and the rear two taking the form of hangers behind the driving axle. There is a steam-driven Worthington oil-pump outside the main frame, in front of the forward turbine (Fig. 4), which can augment the supply from the gear pump, and also circulates the oil through a cooler which is situated under the smoke-box door. This pump can, of course, work when the engine is stationary.

The forward turbine is in permanent connection with the gear-train, but the reverse turbine is only brought into gear, by means of a dog clutch, when it is necessary for backward motion; it does not revolve when the engine is moving ahead, neither can it then be brought into gear. As the forward turbine, on the other hand, is turning when the engine is moving backward, steam is automatically fed to it for cooling purposes under this circumstance.

The steam from the boiler is first controlled by the usual regulator, which is merely used as a stop-valve. It then passes to steam-chests on the turbines, that on the main turbine containing six control valves (Figs. 4 and 6) which are worked from the left side of the cab by a handle placed in much the same position as the reverse-wheel of a reciprocating engine. It is by means of these valves that the speed and power of the engine are varied; the regulator is not moved. The reverse turbine steam chest has three valves (Fig. 6); in the case of both turbines, these valves open in succession, the steam then passing through flexible pipes to groups of nozzles in the turbines. As there is no condenser, the exhaust steam then passes out through the blast-pipes—two in number, this engine having a double chimney—in the usual way. The main turbine, which develops 2000–2500 H.P., has been designed, as regards the number and type of stages, to give high efficiency over a considerable range of engine speed. The steam is superheated to 750 deg. The engine is capable of handling trains weighing 600 tons; that is to say, it has a power equivalent to that of the "Princess Coronation" class, enabling it to do similar work. At a speed of 60 m.p.h., the turbine makes 8900 r.p.m.; at 90 m.p.h., 13,350. The gear ratio between turbine and driving axle is 34·3 to 1. As the reverse turbine is only used for shunting, it is less powerful than the ahead turbine, and has an additional step-down, making four in all (Fig. 6). The control-rods are placed under the casing running along the left side of the engine, the one to the reverse turbine passing across to the right-hand side of the engine, under the boiler.

Where there are such a number of shafts and gearwheels as are found on "No. 6202," efficient and plentiful lubrication is naturally essential, and it is very thoroughly provided for, as has already been described. An interesting auxiliary that prevents the passage of metallic particles—I presume chiefly from the gear teeth—to points where they would be emphatically matter in the wrong place, is a magnetic strainer, which attracts and takes charge of any such intrusive and abrasive material. Another unusual feature is the Timken roller bearings, which are fitted to all the axles, driving as well as carrying. This is the only engine in Britain so completely equipped. at the throat-plate, the tube length being 19ft. 3in. A combustion-chamber is provided, the firebox being Belpaire, with a grate area of 45 square feet; the super-heater provides 832 square feet of the heating surface, which totals 2168 square feet. Two per cent. nickel steel is used in the boiler plates, to reduce the weight, which was necessary in view of the fact that, as has been pointed out, two of the driving axles each carry over 23 tons. As the engine is now running, a dome is fitted, with the regulator in it, the top-feed being arranged a little in front of it, in the standard L.M.S.R. manner.

The smoke-box details are interesting, and differ in some respects from the usual plan, owing to the low pressure of the turbine exhaust. Fig. 7 shows its arrangement. There are double chimneys and blast-pipes, the latter with cones to strengthen the blast, which were formerly automatically adjustable as to their position, being raised as the steam-supply was increased, according to the number of turbine nozzles in operation; they are now fixed. The bell-cranks, with their actuating rods, shown in Fig. 7, are therefore no longer in position.

The tops of the blast-pipes are, as will be noticed, considerably lower in the smoke-box than in the normal type of engine, but the exhaust, after leaving them, is still confined to its passage to the petticoats by pipes that can be looked on as extensions either of the blast-pipes or petticoats, whichever you prefer. It follows that the gases take two courses on their way to the chimneys, instead of the usual one—both through and above these extensions. Deflector plates are now in position by the smoke-box (Fig. 9), and as usual I found them to be very effective in lifting the exhaust steam clear of the cab-windows. Before they were fitted, it was somewhat troublesome owing to the soft blast.

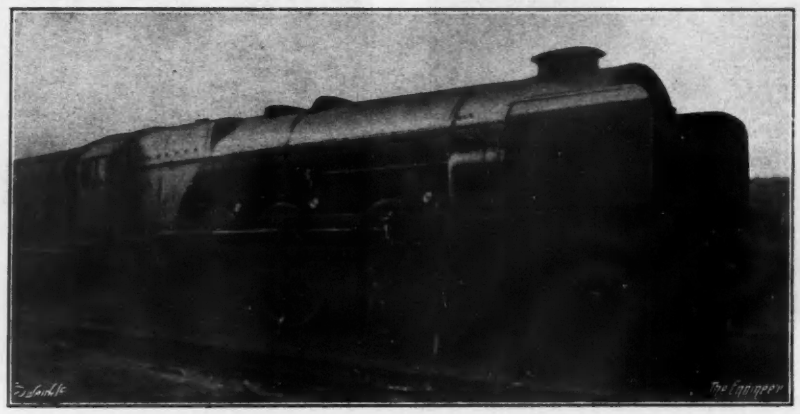

FIG. 9—REVERSE TURBINE SIDE OF "TURBOMOTIVE"

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2 The Engineer, Nov. 7th, 1924, and Feb. 1st, 1925.
3 The Engineer, April 5th, 12th, 19th, and Aug. 9th, 1929.
4 The Engineer, Jan. 1st, 1926, and Jan. 7th, 1927.

(*To be continued*)

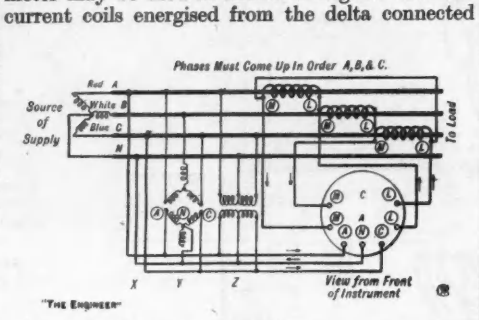
Scientific Instruments and Apparatus

No. IV

(*Continued from page 357, April 12th*)

Nalder Brothers and Thompson, Ltd.

To measure the total power of a three-phase 4-wire unbalanced load system, one of two methods is usually employed. A two-element wattmeter may be used as shown in Fig. 36 with the current coils energised from the delta connected secondaries of three current transformers. The other method, which is often more convenient in practice, is to arrange the secondaries of the three current transformers in star fashion, Fig. 37, thus necessitating a wattmeter with three current coils. On theoretical grounds, the most satisfactory instrument for the measurement of a three-phase 4-wire unbalanced load is a three-element wattmeter. Nalder Brothers and Thompson have developed and placed on the market a series of these wattmeters embodying the firm's improved induction type construction. The series covers all standard indicating instruments, viz., 12in., 8in., and 6in. dial instruments and chart recording wattmeters. The outstanding features of the three-element type are a long circular scale



Scheme X for direct connection to lines.
Scheme Y for connections through three-phase potential transformer.
Scheme Z for connections through two single-phase potential transformers.

FIG. 36—TWO-ELEMENT WATTMETER

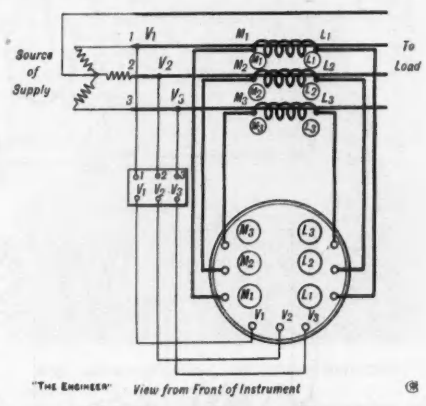


FIG. 37—THREE-ELEMENT WATTMETER

permitting a 300 deg. deflection, high torque, light moving system, and low volt ampere consumption.

Nalder-Lipman induction type wattmeters can be supplied for use on single-phase and balanced and unbalanced polyphase load systems, with scales marked in watts, kilowatts, or megawatts. The improved element consists of two parts—a fixed and moving system. An external U-shaped electro-magnet carrying the shunt winding and internal core of cruciform shape with the series coil on one of the polar projections, constitute the fixed system whilst the moving system consists of a thin aluminium cylinder D (Fig. 38) free to rotate in the air gap between the poles of the external and internal electro-magnets O and I respectively. Between jewelled centres the spindle A rotates and carries the instrument's pointer. As the movement is spring controlled and perfectly balanced, the instrument can be used in any position. Electro-magnetic damping makes it extremely dead beat. A zero adjuster which can be operated from the outside of the case without having to remove the front of the instrument is provided. A single element wattmeter as described is employed for the measurement of single-phase or polyphase balanced load power. For the measurement of polyphase unbalanced load power, two or more such elements are arranged to act on a common shaft, the pointer then indicating the total power of the phases under all conditions of load. The series coil is wound for 5 amperes and the shunt coil for 110 volts. Hence the instruments are suitable for operation from the secondaries of standard current and potential transformers. No resistance boxes are required.

The electrical and magnetic circuits of each element are shown in Fig. 38. V+ and V are the terminals of the potential winding and LM those

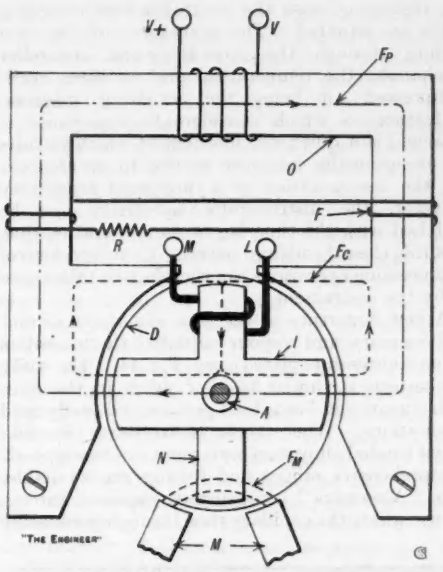


FIG. 38—LIPMAN INDUCTION WATTMETER—NALDER

of the current winding; F the power factor compensation windings and R an adjustable resistance for calibration purposes. Coils F, it will be noted, form a closed circuit of their own. The useful potential flux F*p* circulates along the path indicated by the chain line, thus acting upon the rotor D in a horizontal direction, whilst the flux F*c* due to the current coil LM acts upon the drum in a vertical direction, *i.e.*, 90 geometrical degrees to that of F*p*. The resistance R is so adjusted that the fluxes F*p* and F*c* are also electrically displaced by 90 time-phase degrees. When these conditions are satisfied a torque is exerted upon the moving system D, which is proportional to the power in the circuit, *i.e.* the indications of the wattmeter are equal to the product of volts × amperes × power factor = VA cos ϕ where, of course, ϕ is the phase angle between the load current and the supply pressure.

The main features claimed for these Lipman wattmeters are (1) for a given torque the VA consumption of the windings is a minimum and is lower than that required by any other make of instrument of the same kind; (2) the instruments measure true watts at all power factors and are equally accurate on lagging or leading loads; (3) the readings are practically unaffected by changes in frequency and wave form within the limits met with in ordinary practice.

These and other advantages are said to be inherent to the special construction, the series coil consisting of only a few turns of thick wire placed in the most efficient position inside the rotor D giving a flux F*c*, practically in phase with the current producing it, whereas the potential coil flux F*p* is naturally nearly 90 deg. out of phase with the applied pressure due to both the low ohmic resistance of the shunt coil V+, V and the effective magnetic core on which it is wound. In consequence of the inherently appropriate phase displacement between the two fluxes, the required amount of additional lagging is very small; hence the greater accuracy and permanence of calibration.

For use on interconnectors, the wattmeter can be arranged with "centre-zero" giving clockwise or anti-clockwise deflections according to power flowing in the forward or reverse direction. Unless otherwise specified the instruments are calibrated at 20 deg. Cent. and in the vertical position. Owing to the special method of phase angle compensation, a single element induction wattmeter can be used on a three-phase 3-wire balanced load system without an external star resistance. One single-phase potential transformer and one current transformer are therefore sufficient.

FERRANTI, LTD.

The high voltage indicator, Fig. 39, was to have been shown at the Physical Society's exhibition by Ferranti, Ltd. The instrument cannot be described as new, but it may not be familiar to all electrical people. To protect operators and electrical equipment it is essential that high tension apparatus should be isolated and earthed before any work is begun upon it. The consequence of applying an

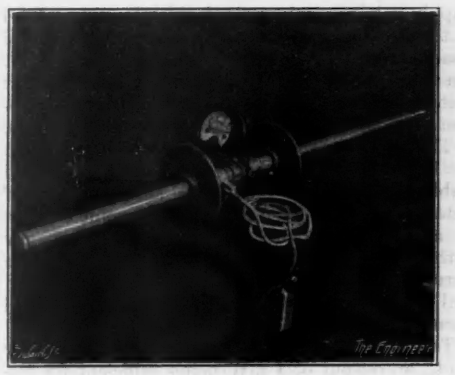


FIG. 39—HIGH VOLTAGE INDICATOR—FERRANTI

earthed connection to a live conductor can be very serious and every possible precaution should be taken to avoid this extremely undesirable practice. As final safeguard a visual indicator should be used to show whether a conductor is "dead" or not. The Ferranti high voltage indicator provides a convenient and reliable means of carrying out a final check. It shows the actual voltage on the conductor to which it is applied and will therefore differentiate between (*a*) a live conductor connected to the system; (*b*) a conductor not connected to the system, but having a much reduced voltage induced in it owing to the proximity of live conductors; and (*c*) a "dead" conductor. It will be appreciated that case (*b*) is one which might be dangerous to the operator yet not be apparent without an indicator showing the actual voltage.

The apparatus consists of a tube 3ft. long, composed of insulating material and carrying a concentric condenser and an electrostatic voltmeter. At the far end is fixed a metal spike which extends down the centre of the stick and forms the centre plate of a concentric condenser. The voltmeter is a dual range electrostatic instrument, and the change of range is brought about by means of a sliding sleeve. On either range the capacity of the condenser is such that the pressure across the voltmeter terminals is not greater than 600 volts, and the current passing through it to earth microscopic. An earth connection of ample section and terminating in a strong clip is provided and it is recommended that this connection should always be used although under normal circumstances a correct reading would be obtained without it. For convenience in handling a non-slip rubber grip is fitted to the lower end and a leather loop is furnished so that the indicator may be hung up when not in use.

Although the indicator is intended for both indoor and outdoor use it should not be used in rain. It should always be kept in a dry condition. Before applying the indicator to a conductor it should be verified that the condenser sleeve is set to give the voltage range appropriate to the system concerned. First the earth clip should be attached to the nearest earth connection when the spike may be placed in contact with the conductor to be tested. A zero reading on the voltmeter indicates that the conductor is "dead" and may be safely earthed. If a reading much lower than the supply voltage is shown it will probably represent an induced voltage from an adjacent live conductor. This conductor may be earthed, but it is recommended all isolators should first be checked and the system voltage checked by applying the indicator to a known live conductor. It is advisable in all circumstances to test the indication of the instrument by reference to a known conductor.

STANDARD TELEPHONES AND CABLES, LTD.

By way of a little diversion one or two electrical communication instruments that would probably have been shown at the exhibition by Standard

FIG. 40—PORTABLE FEEDBACK TRANSMISSION MEASURING SET

Telephones and Cables, Ltd., may now be considered. In Fig. 40 is shown a portable direct reading feedback transmission measuring set designed to measure transmission levels and losses from +25 db. to −55 db. over the frequency range 30 p.s. to 10,000 p.s. New features incorporated

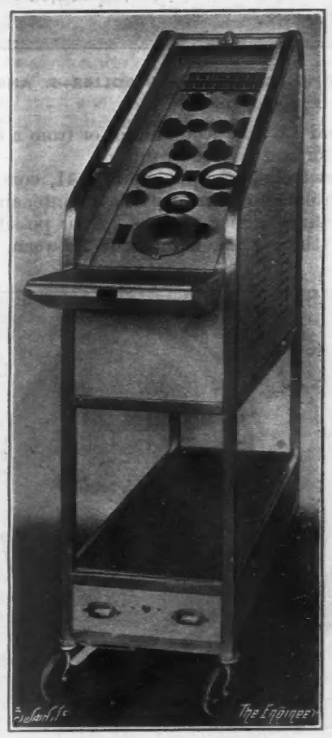


FIG. 41—TEST TROLLEY EQUIPMENT—STANDARD TELEPHONES

in the design tend to increased accuracy, stability, and ease of operation over a wide level measuring range. In the set is a three-stage resistance coupled series negative feedboard amplifier, giving a flat frequency characteristic over the working

frequency range. The calibrated control is situated in the feedback path and after the initial calibration has been made, the gain of the amplifier will remain constant over long periods without re-calibration. The shape of the scale of the output meter is independent of rectifier and circuit characteristics. It is sensibly dependent only on the input signal volts. The output meter scale is therefore calibrated according to the logarithmic DC law and complete interchangeability is possible in the event of damage. Even illumination of the 5in. scale enables readings to be easily discernible at several feet from the set. Power may be obtained from repeater station supplies or from a 130 volt HT battery and a 6 volt accumulator or from a 6 volt accumulator and a vibrator unit.

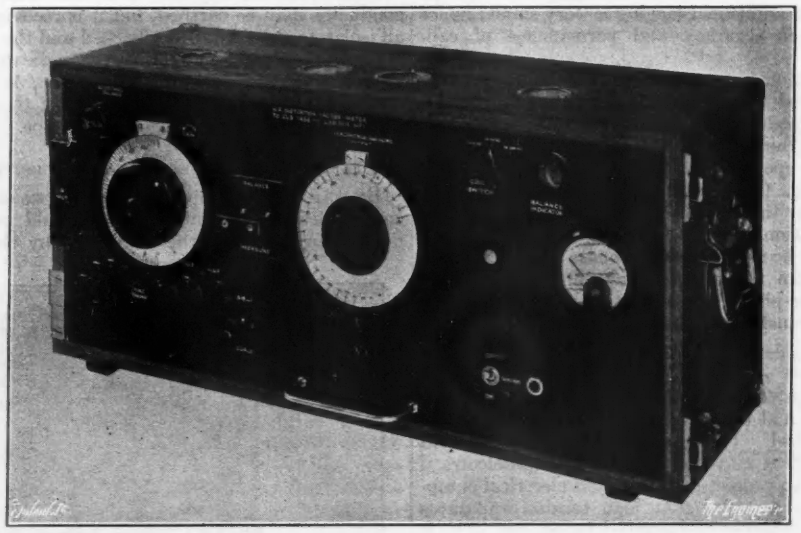


FIG. 42—HIGH FREQUENCY DISTORTION FACTOR METER—STANDARD TELEPHONES

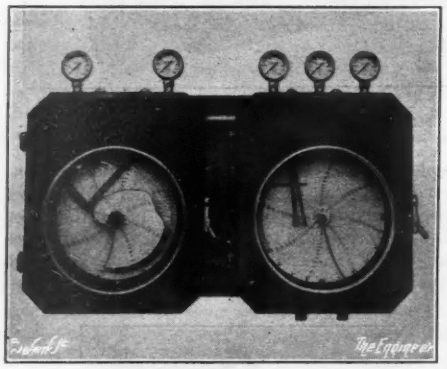


FIG. 43—TIME SCHEDULE CONTROLLER—S. AND M.

The test trolley equipment, Fig. 41, comprises transportable apparatus for the maintenance of twelve-channel carrier systems. It is possible to transport the testing equipment between bays,

FIG. 44—DIAL THERMOMETER—S. AND M.

thus obviating the necessity for long leads and consequently loss and eliminating interference problems met with when dealing with high frequency measurements. Equipped with a voice frequency heterodyne oscillator, a carrier frequency oscillator, a transmission measuring set, harmonic measuring filters, a portable level meter and a valve test set, the following tests may be carried out with the equipment: (*a*) quality tests; (*b*) transmitting and receiving amplifier gains; (*c*) harmonic generation in transmitting and receiving amplifiers; (*d*) channel amplifier gain; (*e*) insertion loss of channel filters; (*f*) carrier supply voltage; (*g*) carrier leak; (*h*) output level at terminals and repeater stations; and (*i*) mutual conductance tests on all valves used on the system. On the trolley is a panel properly fused for test connections and designed to allow the equipment to operate from the normal station batteries.

The high frequency distortion factor meter shown in Fig. 42 is also a Standard Telephones and Cables product. It provides a simple means of determining the percentage total harmonic content of a wave form with a fundamental frequency within the range of 3 to 300 kc. The percentage harmonic content is read directly upon a calibrated dial and the measurement made includes all harmonics up to 1 mc.

The distortion range is 0·1 per cent. to 30 per cent., an output of 1 mW being sufficient for the measurement of 0·1 per cent. harmonic content. By means of a series resonance bridge, the output

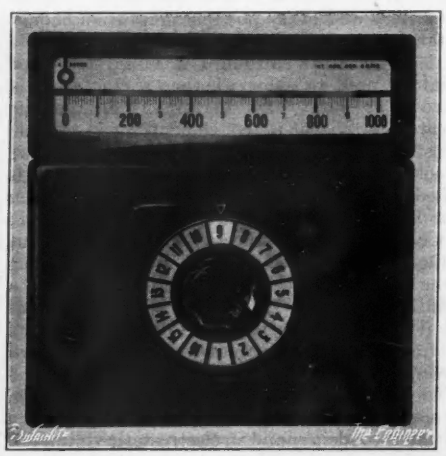


FIG. 45—MULTI-POINT TEMPERATURE INDICATOR—NEGRETTI

of which is fed into a high gain flat amplifier the suppression of the fundamental frequency of the wave to be measured is achieved. A visual indicator in the form of a D.C. millivoltmeter fed through a thermo-couple is used to indicate resonance and gives an R.M.S. indication. To protect the thermo-couple from damage owing to overloads, &c. a quick acting electro-mechanical circuit is arranged to disconnect the thermo-couple heater from the amplifier output.

The device is completely automatic and resets itself when the overload is removed. To assist in obtaining a quick bridge balance a "magic eye" turning indicator is fitted, thus allowing an approximate bridge balance to be obtained without delay as the result of the small time lag of the thermocouple. The input impedance is 10 ohms unbalanced, the maximum input being 2·5 watts. An A.C. supply of 200–250 volts serves to operate the apparatus which is completely self contained.

Short and Mason, Ltd.

A new type of time schedule controller for controlling temperature, pressure, &c. or a combination of these, to a given schedule continuously and repeating the process as required, was to have been shown at the exhibition by Short and Mason, Ltd. The controller, which operates in conjunction with the usual diaphragm valves and similar devices, is housed in two cases as shown in Fig. 43. The left-hand case contains the cam mechanism, whilst in

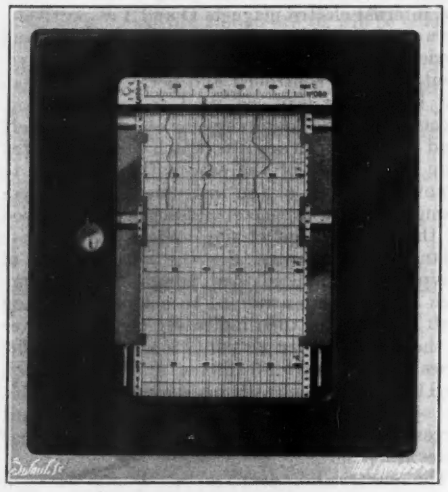


FIG. 46—MULTI-POINT RECORDING THERMOMETER—NEGRETTI

the right-hand case the controller and recording parts are situated. The curvatures of the cam dictate through the recording and controller mechanism the temperature and pressure cycle, compressed air being the actuating medium. A feature to which considerable importance is attached is a quick rise mechanism which permits an exceptionally fast rate of rise to be secured. By the incorporation of a universal sensitivity adjuster, the instrument's sensitivity can be matched with the time lag of the apparatus, thus ensuring close throttling control. Complete control of processing operations can therefore be taken care of by the instrument.

A new departure of the firm is a range of 6in. dial mercury and vapour actuated thermometers in brass chromium plated cases, Fig. 44. The study mechanism is similar to that fitted in the 8-in. instrument, and has a bold pointer and easily read graduations. Where there is excessive vibration a heat treated alloy steel movement can be supplied. Comprehensive ranges and fittings are available, also "Accuratus" compensated capillary tubing, for use where the capillary runs through fluctuating

FIG. 47—PYROMETER CONTROLLER

temperature zones to prevent these fluctuations being transmitted to the indicator.

Negretti and Zambra

The Negretti and Zambra temperature indicator shown in Fig. 45 is available as a single- or multi-point instrument. It has a sensitivity of 20 ohms per millivolt, and is fitted with automatic cold junction control. The illuminated or anti-parallax scale is 10in long. A rotary selector switch consists of a mercury tube which ensures freedom from

contact resistance and is tilted through an angle of 90 deg., making the instruments suitable for marine use. As the contacts are hermetically sealed there are no risks of explosion when the instrument is used in an explosive atmosphere. The point connected to the indicator is shown by an illuminated index.

The new Negretti and Zambra multi-point recording thermometer shown in Fig. 46 will give one, two, or three records in different coloured inks on a chart 5in. wide and has a numerical indicator showing the number of thermo-couples being recorded. The working mechanism is designed for use on a 200/250 volt single-phase supply. It is not available with a spring-wound clock drive.

The Negretti and Zambra pyrometer controller shown in Fig. 47 has been produced to meet the demand for an instrument with a sensitivity of 20 ohms per millivolt, automatic cold junction control, a 10in. illuminated scale and valve position signal lights. It can be arranged for "on-off" control, "floating" or "throttling" control, or two-speed valve operation.

(To be continued)

Acceptance Test Charts for Machine Tools

THE earliest alignment charts, with few actual tests, were published between 1900 and 1907 by British and American machine tool makers, and were used only to show the results of the inspection of the machine tool in the manufacturer's works before delivery. In 1901, Dr. G. Schlesinger, then Chief Engineer of the Ludw. Loewe Company of Berlin, was asked to arrange acceptance charts for the use of that firm in its own works, and for its own products, but as no recognised system of fits and tolerances existed at that time, there was no relation between the accuracy of the work produced and the machine producing it. By 1903, a set of 40 test charts had been developed, to cover a variety of machine tools, and were put into daily usage by Ludw. Loewe. The numerical values of the charts were elaborated by the Research Department of the Charlottenburg University from 1904 onwards. The first publication of a test chart showing tests and alignments as a manufacturing basis for machine tools, was made in Germany in September, 1909, using a universal milling machine as an example.

During the period 1909 to 1931, Dr. Schlesinger was Chairman of the Standards Committee of the German Machine Tool Makers' Association. In 1910, he proposed that the Association should adopt his charts for tests and alignments, but the proposal was rejected on the grounds that uniformity and classification of detailed tests were impossible. Shortly after this, the Russian Government placed large orders for machine tools in Germany, stipulating acceptance of the machines in Russia, but did not define their tests. To obtain data, the Russians collected information from German firms, and selected from the figures supplied to them the closest specification of tolerances that they could find in the various types of machine tools. As a result, specifications were produced with tolerances which, in many cases, were unnecessarily fine, unsuitable, and too costly. These arbitrary charts led to the rejection of a large number of German machine tools, and to settle the controversy which developed the parties nominated Dr. Schlesinger as arbitrator, on the understanding that he would be free to prescribe the final acceptance tests.

In September, 1927, the first edition of the Schlesinger book describing this work was published and adopted by the Russian Government and the German machine tool industry. As a result, some of the German makers had to change their manufacturing organisation in order to produce quality work, but did this with such success that the reputation of their machines rose greatly in the international market. In the French translation of the book (1929), a clear line was drawn between the accuracy of the machine and the accuracy of the piece finished on the machine, and the distinction between the two types of tests was made by classifying them as "Geometric" and "Practical" tests respectively.

In 1933, Lieut.-Col. P. Salmon (Head Inspector of the French Government, and purchaser of machine tools for the whole of its national services) expressed the view that it was necessary to stipulate the conditions under which the practical tests should take place, and that only in exceptional cases was it necessary to insist on tests and alignments for the machine tool. He further advocated that the measurement (or geometric tests) of machines should only be carried out at the express wish of the purchaser. He thus emphasised that working tests were essential, and that subsequent static tests might be optional. At the present time amplified proposals by Lieut.-Col. Salmon have been placed before the I.S.A.* Committee 39.

The conflicting claims of the Schlesinger "geometric" and the Salmon "practical" systems for use as an international standard have been discussed by the I.S.A. Committee over a long period and have prevented agreement. The controversy began in 1936 at Budapest and Berlin, and was continued in 1937 in Paris, in 1938 at Stockholm, and in 1939 in Rome and Helsinki. Dr. Schlesinger claimed that practical or working tests were an inseparable part of the acceptance of the machine, in order to prove that the mounting of the machine was correct. This is of importance, for it should be noted that acceptance tests do not make provision for measurement of the parts of a machine tool, but for measurement of the accuracy of the assembled machine. This means that all the tolerances admissible in the manufacture of the individual parts have been utilised in order to introduce the necessary accuracy into the sub-assemblies and final erection. It is essential that the machine tool maker who applies a standardised fit system (*e.g.* the B.S.I. system, Grade B-U-V-W, superfine fits, &c.) to the production of his separate parts, should assemble these parts into the machine in such a way that variations within the permitted tolerances are equalised. The work produced by the machine will then be within the general permissible accuracy of the complete machine.

The I.S.A. meetings generally comprised representatives of six nations: Germany, France, Italy, Belgium, Sweden, and Switzerland. Great Britain and America, up to the present, have taken no part in this work officially, and the British Machine Tool Trades Association, although interested in what was happening in France and Germany, did not take corporate steps to put forward any standards for machine tool alignments.

In 1937, Mr. H. C. Armitage of the Austin Motor Company, Ltd., tested out 300 new machine tools (mostly British) against Schlesinger standards, and the experience then gained showed:—(1) That there was an enormous advantage to the machine tool user in testing out the machines, both geometrically and practically, when they were actually fixed in the users' works; (2) that first-grade machines were being generally constructed to closer tolerances than those advocated; (3) that Schlesinger charts in their present form were not entirely suitable for the requirements of tests *in situ*. Advantage was gladly taken of this valuable experience by the Institution of Production Engineers when its Research Committee decided, as one of its first objectives, to formulate proposals for acceptance tests for use in British works.

The basis on which the I.P.E. charts have been prepared is that of codifying a standard of acceptance after the machine tool has been fixed in the user's workshop, and it has been reduced to the simplest practical form requiring the minimum of measurement. The charts are not intended for the practical use of the builder of machine tools except for the purpose of giving him a guide and a standard for reference in cases of dispute. The tests now cover the experience of a large number of production engineers, and have been arranged so as to embody the basic requirements of the two main existing systems, the "geometric" and "practical" tests respectively. The test sheets are available in a form which makes them suitable for instant practical use, and in the hands of a competent inspector they will ensure the advantages accruing from the knowledge that the machine tool is of an accuracy that production engineers can justly demand in order to have confidence in the work that will be produced. It is hoped that the great amount of detailed work which has been carried out in producing these charts will materially assist in their acceptance as a standard, and so end the controversy which has been carried on for so many years.

* International Federation of National Standards Associations.

IN connection with the above we have received from the Machine Tool Trades Association a copy of a circular letter which it has issued to its members:—

MACHINE TOOL TESTS AND ALIGNMENTS

Dear Sir(s),—Representations have from time to time been made by this Association suggesting to the Institution of Production Engineers that joint consideration of the above subject should be deferred until after the war. It was felt by the Association that those members of the machine tool industry best qualified to enter into joint deliberations on this subject could not be spared from their task of contributing their utmost to the national effort by way of increasing the production of machine tools.

Notwithstanding these representations and the fact that the British Standards Institution did not regard it as practicable at the present time to proceed with the question of preparing any British Standard Test and Alignments for Machine Tools, the Institution of Production Engineers, in collaboration with the Institution of Mechanical Engineers, have published acceptance charts for machine tools, and have expressed their intention of publishing still further charts to cover a wide range.

In these circumstances, the Council of the Association, at a meeting held on April 3rd, decided that they had no other alternative than to make it known to the machine tool industry that the Association have had no part in the preparation of these acceptance charts, and must advise their members not to accept orders conditioned on conformity with these charts.

It is regarded as elementary that publication of these charts should not have taken place without the fullest concurrence of the industry, and that the present time is an impossible one in which to obtain such concurrence.

Yours faithfully,
pp. W. J. MORGAN.
Secretary.

Provision of Engine Power on South African Railways

THE extent of the provision made to increase engine power and truckage on the South African Railways during the past five financial years is reflected in the following particulars of locomotives and goods wagons placed in service during that period, as well as the numbers of such stock placed in service up to September 30th, 1939, and on order, under construction, or authorised at October 1st, 1939:—

	Steam and Electric Units	Trucks
1934–35 placed in service	43	1363
1935–36 ,, ,, ...	32	2459
1936–37 ,, ,, ...	47	5730
1937–38 ,, ,, ...	60	2553
1938–39 ,, ,, ...	260	4426
Placed in service, April 1st, 1939 to September 30th, 1939	99	1020
Authorised on order or under construction at October 1st, 1939	29	2837
Total provision since 1934–35	570	20,388

Two internal combustion shunting engines were also placed in service during 1938–39.

At the close of the year 1939, the Administration's steam locomotive stock consisted of 2175 engines of 3ft. 6in. gauge and 64 of 2ft. gauge, as against 2019 and 63 respectively at the end of 1937–38. Two hundred and ten standard gauge locomotives and one 2ft. gauge engine were placed in traffic during the year, while 54 standard gauge engines were withdrawn from service. The new standard gauge locomotives comprised 94 class 23, 42 class 15F, 58 class 19D, and 16 class G.M., representing a total tractive effort of 8,657,580 lb. The 54 engines withdrawn from service represented a loss of 1,325,030 lb. in tractive force, but in addition to the new engines placed in service, an increase of 321,019 lb. in the total tractive effort available to the Administration was brought about by the recalculation of the boiler pressure of certain classes of locomotives which were fitted with standard boilers. Forty-nine electric units were placed in service during the year, bringing the total up to 172, with a total tractive force of 3,633,700 lb., including one battery shunting locomotive with a tractive effort of 8500 lb. The comparative figures at the end of the previous financial period were 123 units with a total tractive force of 2,594,900 lb.

Direct-Coupled Roller Motors

IN modern rolling mill practice individual motor drive for the roller tables in preference to a group drive in which one motor is used to drive a number of rollers through gearing is found to present several advantages. We might mention :—(1) Simplified design of the roller tables, as dead alignment between adjacent rollers is not essential ; (2) each roller, with its driving motor forms a self-contained unit, which can be replaced in a short time if required ; (3) reduced maintenance costs as a result of the absence of gearing, shafting, and difficulties of exact alignment ; (4) fewer operating shut-downs, as an individual roller can be cut out without interrupting the operation of the roller table ; (5) ease with which the various parts of the mill can be synchronised since the roller motors are supplied from a common source and their speeds are, therefore, uniform ; (6) speed

FIG. 1—MOTORS ON RUN-OUT TABLE OF A HOT MILL

variation of the roller motors can be obtained by means of a variable frequency converter ; and (7) higher overall efficiency as a result of the absence of gearing.

A comprehensive range of low-frequency motors, designed and constructed for this service, is manufactured by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. These machines are direct-coupled to the rollers through flexible couplings. They are built on robust lines, both mechanically and electrically, and are available in totally enclosed, fan-cooled pattern (Fig. 1), and a totally enclosed pattern without the fan (Fig. 2). In the first-named type a fan, situated outside the motor shell, forces a continuous stream of air over the outside of the shell to assist the dissipation of

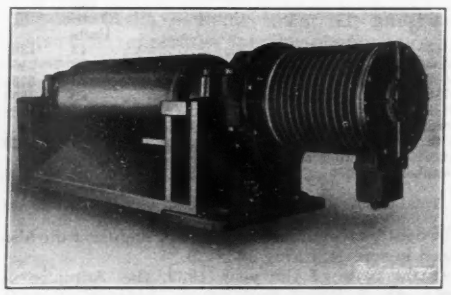


FIG. 2—LOW-FREQUENCY MOTOR

heat. The fan is enclosed by a cowl which assists in directing the cooling air across the motor frame.

By designing the machines to run on a low-frequency supply it is possible, in most instances, to obtain the high torques required for acceleration and retardation without resorting to specially constructed high-resistance rotors. Another advantage is that the size and cost of the motor can be reduced considerably as compared with machines operating at the normal 50-cycle frequency. Furthermore, although a frequency converter forms a necessary part of the equipment, the total cost of the installation compares very favourably with that of specially designed 50-cycle motors.

The stator shell is made of cast iron or steel and is heavily ribbed to provide adequate cooling surface. Its diameter is reduced as much as possible, and is usually less than that of the roller to which the motor is coupled so that floor plates can be placed over the machine if desired.

The winding consists of asbestos covered wire which is insulated from the stator slots by micanite so that the complete winding is practically fireproof. In the end windings additional insulation is provided between phases, which are separated from each other by flexible strips of micanite. After the winding is completed the stator is dried out and, while still hot, is immersed bodily in a special insulating varnish. Finally the completed stator is baked.

The rotor winding usually comprises a number of copper or bronze bars which are oxy-acetylene welded to end-rings to form a squirrel cage winding. The insulation between the copper bars and the iron core consists of troughs of anodised aluminium placed in the rotor slots. In some cases aluminium windings, die-cast in one piece, are used.

Ball and roller bearings are provided, special grease nipples being fitted for lubrication purposes. The bearings are housed in cast steel end brackets, one of which forms the flange for securing the motor to the roller. This flange can be made to suit any standard type of roller, and is so constructed that ample space is available for fitting the coupling. The terminal box is mounted on the underside of the stator frame, and is so designed that the terminals

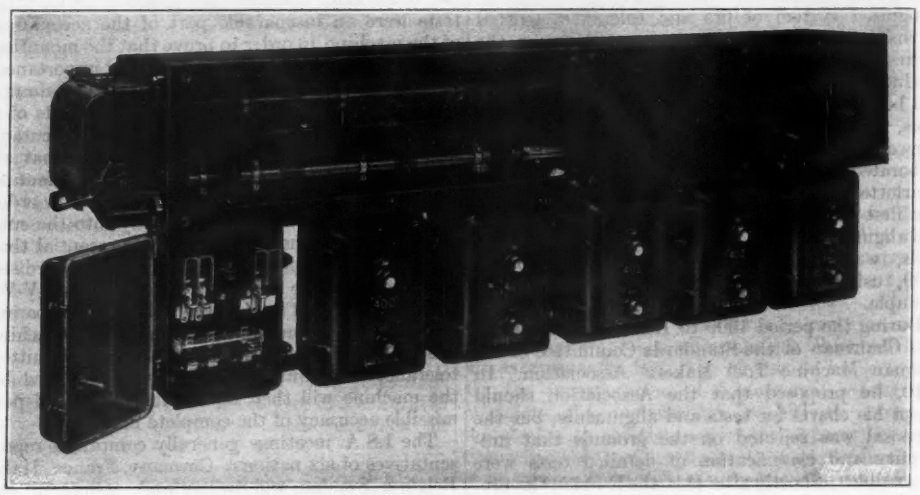


FIG. 3—THERMAL OVERLOAD CUT-OUTS

are readily accessible. With this arrangement the terminal box is conveniently situated to receive the incoming cables.

The motors operate from a low-frequency supply so that the starting current is reduced to a small value, while the starting torque given by the motor is high. If desired, arrangements can be made for reversing the roller motors by a set of contactors which form part of the control equipment. When the equipment is designed for this service, the motors can be " plugged " to give quick stopping.

The motors are supplied from a frequency converter which can be either of the constant-frequency or variable-frequency type, dependent on whether constant- or variable-speed drives are required. Constant-frequency converters are usually driven by induction motors operating from the A.C. mill supply system. If variable-frequency is required, the converters are driven by variable-speed D.C. motors. With this arrangement, the roller motors of the working tables can be started up at the low frequency and rapidly accelerated or retarded by varying the speed of the converter and consequently the frequency of their supply.

It is possible to supply a complete installation from one converter even when different table speeds are required, but a more desirable cable layout may be possible by installing a number of converters, each supplying its own set of roller motors.

The control equipment for the roller motors is of the contactor type arranged for remote operation from master controllers. For each group of motors, the equipment includes a triple-pole main isolating switch and two triple-pole heavy duty reversing contactors fitted with roller bearings and designed for very frequent service—up to 750 operations per hour. Protection is afforded by cartridge high-rupturing capacity fuses and no-volt relays. The relays are so arranged that they will trip the main contactors in the event of failure of the constant or variable frequency supply to the unit. If the relays have operated, the contactors can only be reclosed after the master controller has been returned to its off position.

Where the control equipment is to be installed in the same building as the mill itself, it is enclosed in dust-proof sheet steel cubicles arranged as a single switchboard. Front access doors are fitted, and are interlocked with the main isolating switches so that access to a cubicle cannot be obtained unless the appropriate isolator is in its off position, neither can the isolator be closed while the door is open. Alternatively the control gear can be installed in the motor room remote from the mill. Under these conditions trouble from dust and dirt is obviated and open type contactors can be used, the equipment being mounted in the form of a flatback switchboard.

Each pair of reversing contactors is arranged to control a group of motors. For the protection of each motor, therefore, either a triple-pole ironclad switch with fuses or a triple-pole contactor with thermal overload releases is supplied. Protective units can be mounted alongside each motor, connection boxes being provided to permit " looping in " the main power cable, which runs along the whole length of the roller tables. In an alternative arrangement, the protective units are mounted on a bus-bar chamber to form a complete assembly (Fig. 3) which can be mounted in a convenient position near the motors. This scheme possesses the advantage that it is only necessary to provide heavy power cable to each set of protective units from which smaller cables are taken to individual roller motors.

The master controllers for actuating the reversing contactors are shown in Fig. 4. They are of the lever-operated steelworks pattern with forward, reverse, and off positions. Contacts are provided in the off position for resetting the no-volt relays.

For the control of the alternator of the frequency convertor an open type flatback switchboard is usually supplied. On this switchboard is mounted a triple-pole line contact circuit breaker with over-current releases, alternator field contactor, a hand-operated alternator field regulator, and the necessary instruments, which include a voltmeter, ammeter, and frequency meter.

For constant-frequency converters, the A.C. driving motor is controlled by standard starting equipment which may comprise an auto-transformer

FIG. 4—MASTER CONTROLLERS

starter and circuit breaker, or stator switch with oil immersed or liquid starter depending on the type of driving motor employed. Where the frequency converter is driven by a variable speed D.C. motor, the whole of the equipment for controlling this motor is mounted on the same flatback switchboard as the control gear for the alternator. This apparatus includes a double-pole

line contact circuit breaker or contactor, depending upon the rupturing capacity required, shunt lock-out or time-element-controlled accelerating contactors, over-current releases, ammeters, a shunt regulator, and a field interlocking relay which enables the motor to be run up to any predetermined speed depending upon the shunt regulator setting. This arrangement permits the frequency of the converter to be set at any desired value.

The speed of a variable frequency converter and consequently its frequency is controlled by the hand-operated shunt regulator in the fields of the D.C. driving motor. Where desired arrangements can be made for remote speed control from push-buttons on the control desk.

A further method of control consists of connecting the shunt regulator of the variable-frequency converter to the speed regulator of the D.C. mill motor. With this system the frequency of the supply to the roller motors is varied automatically with any alteration in the speed of the mill motor. The speed of the roller motors therefore varies automatically with the rolling speed.

Hot Air Power Plant*

By Dr. J. ACKERET and Dr. C. KELLER.

THE new working cycle employed by Escher Wyss, as seen in Fig. 1, is a closed cycle, in contradistinction to the cycle of an ordinary gas turbine, seen in Fig. 2. This plant contains a gas heater, a regenerator, a compressor and a turbine. The heat is supplied through metal surfaces. The working agent is primarily air, but other gases can also be used, since we have to deal with a closed cycle.

The changes of state are seen in the entropy diagram, Fig. 3. The expansion in the turbine takes place along the line AB, the regeneration along the line BC or DE. In the compressor the air is compressed isothermally, whenever possible, from C to D. In actual practice this is done in several stages with intercooling in between. The heat from the outside is supplied to the working medium in the air heater along the line EA. This completes the cycle.

The area ABCD in Fig. 3 of the ideal cycle represents the work done. It is the difference between the work done by the turbine and that used for the compressor. The work performed by the turbine for 1 kg. is equal to the heat supplied from the outside EAJH. The work used for the compressor is equal to the heat given up to the cooling water of the compressor DCGF.

Assuming an ideal gas for the working medium, and this is very nearly the case for air, the thermal efficiency of the ideal cycle, that is not considering the losses in the turbine, compressor, gas heater, and heat exchanger, and assuming complete regeneration, Fig. 4, is given by :

$$\eta_i = \frac{C_p(T_1-T_2) - ART_2\log\frac{p_1}{p_2}}{C_p\,(T_1-T_2)} = 1 - \frac{ART_2\log\frac{p_1}{p_2}}{C_pT_1\left[1-\frac{1}{\left(\frac{p_1}{p_2}\right)^{\frac{k-1}{k}}}\right]}$$

From this it is evident that for a given maximum temperature T_1 and a minimum temperature T_2, the thermal efficiency of an ideal cycle only depends upon the ratio of the pressures, and not on the absolute magnitude of the pressures, between which the cycle operates. The smaller the ratio of the pressures, the higher the efficiency. In the limit the efficiency of the Carnot cycle is obtained. This also holds good approximately for a process of operation in which losses occur. This is a great advantage compared with the usual process employing steam for the working agent, for in this latter process the available heat cannot be utilised efficiently, unless the steam is used at high pressures and high temperatures. It cannot be denied that the use of high pressures has made great progress in late years as applied to steam power plants, but it should be noted that the use of high pressures is accompanied by a number of disadvantages, such as first cost and maintenance of complicated apparatus, valves, and safety appliances, which are subjected to stresses caused by the high pressure. For a turbine plant operating on the closed cycle as described we need no increase of pressure to increase the efficiency.

An examination of the entropy diagram in Fig. 3 will at once reveal the large amount of heat still contained in the gas, after performing work in the turbine, which is placed behind the gas heater.

It is indispensable to make further use of this heat, since the waste of heat with free discharge as in usual gas turbine plants would be so great that such plants would not be able to compete with a steam plant of even moderate efficiency. Here we have a difficulty to contend with which must receive very careful attention if our plant is to be a success. A so-called regenerator which would deal with this heat in a free discharge-plant, and in which the heat is given off to the cold air from the compressor, the heat exchange taking place continuously in a counter-flow system with minimum loss of pressure, would have to be of such large dimensions that the first cost would annul any advantages obtained by the high thermal efficiency. This is particularly the case when internal combustion takes place to generate the heat and the cross sections of flow must be big so as not to be choked with impurities and solid matter, as products of combustion.

When, however, the fire is kept out of the closed circuit system, and the entire circuit is made to operate under pressure, the cross sectional areas can be made much smaller, and also the surfaces, since transmission of heat is nearly proportional to the pressure.

There are other advantages connected with the use of a pressure-circuit. The coefficient of heat transmission on the gas side of the gas heater is better, so that the mean temperature of the wall is lower and moved considerably nearer to the cold gas side than would be the case with low pressures. Both turbine and compressor can be made of much smaller dimensions, and in spite of this they operate at higher Reynolds-numbers. Thus with an initial pressure of 9 atmospheres at the inlet side of the compressor, instead of the atmospheric pressure as is usual with the open cycle process, and for equal temperatures and speeds, the diameters both of turbine and compressor can be reduced to one third, with a corresponding saving of costly material. In spite of this, the Reynolds numbers would correspond to a diameter nine times as great, that is to say three times as great as compared with a plant of open circuit. Of equal importance is the ease and convenience with which control can be effected, merely by altering the pressure in the circuit, or in other words, the density, without altering either the temperature or the speed. If the inlet pressure to the compressor were to be reduced to 1 atmosphere absolute, bearing in mind the data as stated above, the output would be reduced to $\frac{1}{10}$. Since the velocity triangles of all the stages of the compressor and the turbine remain unchanged for constant speed of rotation, the efficiencies of the compressor and the turbine are only affected by the Reynolds numbers. This holds good for all pressure ratios or number of stages. By lowering the pressure of the closed circuit, and this can be reduced to a vacuum pressure in the closed system, the power to start the plant can be reduced very considerably.

The exhaust from the turbine flows through the regenerator and gives off heat to the air flowing from the compressor to the gas heater. This latter does not come into contact with any cold medium, and a considerable amount of the flue fire-gas heat would be lost if the waste heat from the gas heater were not utilised for pre-heating the air for combustion, or for some industrial process. The cooled regenerator air is cooled down still further, so that the air at the inlet to the compressor may be as cool as possible. This additional cooler and the cooler for the compressor air are the only sources from which heat is

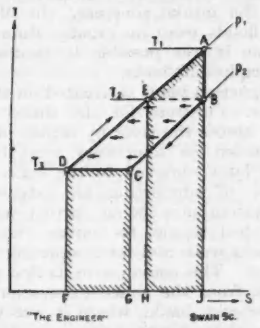
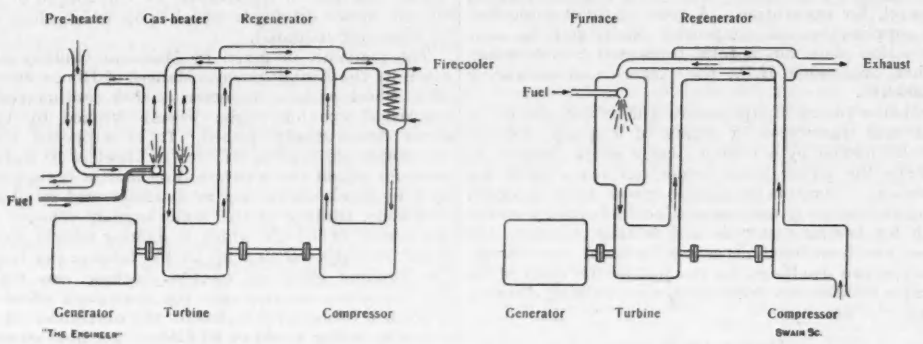


FIG. 3—ENTROPY DIAGRAM



FIGS. 1 AND 2—ESCHER WYSS AND ORDINARY TURBINE CYCLES

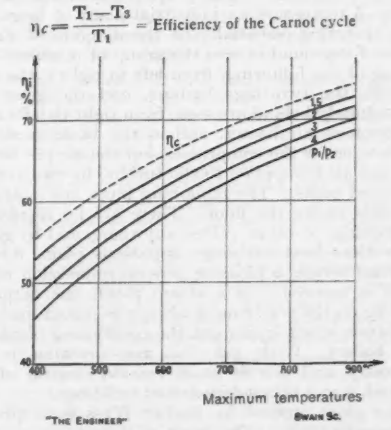


FIG. 4—EFFECT OF RATIO OF PRESSURES ON EFFICIENCY

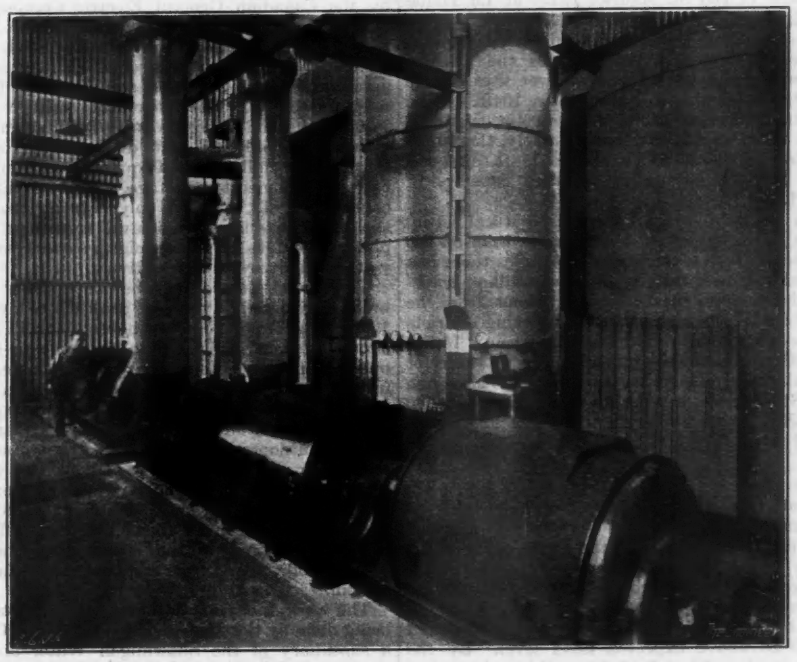


FIG. 5—CLOSED CYCLE HOT AIR PLANT

* From the *Escher Wyss News*.

extracted (excepting the losses from the flue gas). It will be evident that the cooling water required for a plant of this kind is only a fraction of that used by a steam plant of the same output, especially as the temperature of the water can be raised considerably without causing any harm. Particularly pure water is not required, since the water does not come into contact with any delicate parts (water is not used for cooling the blades, and so forth). All difficulties associated with the supply of water as for a high pressure steam plant are non-existent, this being a great asset in favour of the plant described, as it also is of the ordinary gas turbine. This is a point of great advantage that must receive careful consideration when laying out any power plant in the future.

The total plant actually represents a kind of surface heating plant, not unlike a chemical plant. The actual machines incorporated in the plant are of compact design, but the reactions that take place in these machines are of paramount importance for the economical operation of the plant, and fully justify the industrial development and the demand for the most exacting accuracy in the process of manufacture.

Fig. 5 represents an industrial plant of large output, operating essentially on the diagram of Fig. 1. In the foreground is seen the group of machines consisting of the following, from left to right: the compressor, the two-stage turbine, and the generator. Immediately behind are seen (from right to left): the regenerator, air heater, and in the background the intercooler for the compressor and the air pre-heater. The hot air is supplied to the turbine by two vertical insulated pipes. The remaining pipes are located in conduits under the floor. There are no regulating, controlling, or other valves anywhere, and by giving the various heat exchange apparatus plain, modern outward forms, a pleasing general impression of the plant is secured. In a steam plant, the action of gravity on the water must always be taken into consideration when laying out the condensing plant and the boilers. With gas this consideration is not necessary and one is more free to dispose of the general layout of machinery and buildings.

The plant erected by Escher Wyss is at present undergoing trials. The result of these trials together with the many possibilities of future developments and use for propulsion of ships, or rail, or road vehicles, will be published by the firm at some future date.

Canadian Hydro-Electric Development

There is now under way at La Tuque on the St. Maurice River, in the Province of Quebec, a hydro-electric development that is of particular interest to the pulp and paper industry. Brown Corporation and the Shawinigan Water and Power Company are equal proprietors of the St. Maurice Power Corporation, which is developing the well known La Tuque Falls, situated within the municipal boundary of the town of La Tuque. While the ultimate development will consist of six units, only four are to be installed immediately, having a capacity of 40,500 H.P. each. The output of this new development will be absorbed by the Shawinigan Water and Power Company and by the Brown Corporation.

The flow of the St. Maurice is controlled by very large storage basins in its upper reaches and those of its tributary, the Manouan, by dams operated by the Quebec Streams Commission. At present the continuous flow of the St. Maurice River at La Tuque seldom drops below a minimum of 13,500 c.f.s., while the maximum expected flood stage is about 120,000 c.f.s. The La Tuque site is the farthest downstream of a group of seven power sites on the Upper St. Maurice river, and utilises 104ft. of the available total head of 726ft. Only one other of this group of seven sites is developed, namely, the centre site at Rapide Blanc, which utilises 112ft. and was built in 1931–32, having an installed capacity of 160,000 H.P.

Seldom will be found a more ideal natural set-up for power development on a single river than on the St. Maurice. Over a stretch of 185 miles there is a possible ultimate capacity of over two million horsepower, all within easy transmission distance from the centre of one of the greatest manufacturing districts on the continent. The total drainage basin is 15,740 square miles, while in the upper reaches of the river and its tributaries, above the junction of the Manouan and the St. Maurice, is a drainage basin of over 6540 square miles, where already a storage of 220 billion cubic feet is developed.

Construction

In March, 1938, a start was made on the installation of the construction plant, and work began on cofferdams to de-water the site of the sluice gates on the west side of the river. Throughout the summer a force averaging 900 men worked steadily, completing the construction plant, de-watering the west half of the river-bed and building the sluice gate section and west wall to above expected flood level. By the end of November this cofferdam was blasted out and work started on closure of the cofferdam to block the east half of the river-bed where the power house is situated, while by the end of the year the flow was turned through the partly completed sluices, and excavation for the intake and power house foundations was begun.

By March, 1939, foundations were poured for a steel trestle immediately downstream from the intake and gatehouse, and from which the placing of forms, reinforced concrete, and penstocks, could be carried out by means of four electrically-powered travelling derricks. This trestle will eventually become embedded in the intake concrete. In May of 1939 the spring floods were no greater than anticipated and by June it was possible to continue with all work on a triple shift basis.

The construction plant is situated on the east bank of the river. Concrete for the sluice section was transported across the river by means of a belt conveyor supported on temporary steel bridge spans which were later removed to the sluice section for the purpose of supporting an extension of this conveyor system now being carried on the aforementioned steel trestle, to convey concrete to the west abutment walls and for completing the concrete in the sluices. This conveyor in its first position also carried rock from the sluice excavation across the river to the east bank, where it was crushed and stored at the concreting plant.

Rock excavated from the power house excavations, consisting mostly of gnessoid granite with intrusions of pure granite, is brought to the crushing plant by trains of dump cars hauled by petrol locomotives. From the storage piles the crushed rock is fed to the mixer bins by belt conveyor. Cement is used in bulk. A battery of two 2-yard Smith mixers feed the conveyor belt through hoppers, the rate of pouring averaging 1600 yards a day during active periods, or 35,000 yards a month. Most of the construction plant is electrically driven, including four electrically-operated shovels, ranging in size from $\frac{7}{8}$ to $1\frac{1}{2}$ cubic yards, and a $\frac{1}{2}$ cubic yard petrol engine operated shovel, for excavation. A total of 3250 cubic feet is supplied by the compressor plant, and the construction plant has a total connected load of somewhat over 4000 H.P., the power used averaging 2000 kW.

Heavy pieces of equipment will be brought in by rail and transferred by means of a special 100-ton trailer hauled by a tractor over a short distance to where the power house crane can reach them for placing. Vibrators are used to ensure dense concrete, and the company maintains a local laboratory on the job for testing materials and testing cylinders. It was not considered necessary to build any camps, except two dwellings, for the job, as the town of La Tuque is within ten or fifteen minutes walking distance from the site.

Design of Plant

There will be five electrically-heated sluice gates—50ft. wide and 31ft. high, and two regulating gates—21ft. wide and 22ft. high, all with individual hoists. There will also be a log sluice. In the gatehouse there will be two headgates—each 15ft. wide by 30½ft. high—for each unit, heated only by fan-type blowers, or a total of twelve headgates as well as one spare set of emergency gates, and one set of tail-race gates for de-watering draught tubes. One open-air-type travelling crane operates all headgates, since there is to be no superstructure over gates and racks.

The turbines, which are being supplied by the Dominion Engineering Company, Ltd., and which will operate under a head of 104ft., will have Francis-type runners. Generators, which are being supplied by the Canadian General Electric Company, Ltd., will have an air-circulating cooling system by which air for cooling will be screened, cooled, and re-circulated, a precaution considered necessary on account of the prevalence of sulphur fumes from pulp mills close by. The generator voltage will be 11,000 volts and since one-half of the output is to be transmitted only a short distance to the Brown Corporation mill at La Tuque this current will be carried at generator voltage. A total transformer capacity of 112,000 kVA only is being provided for the initial installation, which will transform whatever power is fed to the Shawinigan system at 220,000 volts for delivery to Three Rivers.

The switch house will be an entirely separate building situated on the east bank of the river, about 100ft. away from the power house. It will house the circuit breakers, which are to be of the air-blast, air-operated type with electrical control, instead of the usual oil-filled type. It will also contain air-compressors for switching gear, air-drying equipment, carrier current, and relay protection. Transformers will be outdoors between the switch house and the river bank; one transformer bank will be cooled by circulation of oil through a water heat-exchanger. Neither in the power house building, where space is provided for a control room, executive offices, and locker rooms, nor in the switch house will there be any oil, apart from the generator lubricating system.

The work, including design and construction, is all being done by the Shawinigan Engineering Company, a subsidiary of the Shawinigan Water and Power Company, with its own forces.

Railway Brake Shoe Testing Machine

The number of cast iron brake shoes used in recent years by the French National Railways has rapidly increased, partly as a result of increases in train speeds and weights, and partly because of the introduction of continuous braking systems on goods trains. In particular, the braking effort on express trains has had to be increased, in order to ensure the bringing of the train to a standstill within distances dictated by the positions of signals, for in many cases it is not practicable to increase these distances. Moreover, the braking system, rather than the power of the locomotive, has been found to impose a practical limit on train speeds. Furthermore, the consumption of brake shoes, now more than 20,000 metric tons per year, is very large and improvements resulting in reduction of the rate of wear would make considerable economy possible.

Faced with this double problem of improvement and economy, the French railways recently ordered a brake shoe testing machine, which has been installed at the locomotive test bed at Vitry-sur-Seine, near Paris. We are indebted to our contemporary, *Le Génie Civil*, for the particulars of this machine given below.

In designing the machine account was taken of the two types of braking necessary in practice, namely, the stopping effort necessary to bring a train to rest in a short time, with the train speed rapidly decreasing from the maximum to zero, and the more moderate braking required on long, steep inclinations, when the brakes must be applied for a considerable time in order to maintain a constant speed. To meet the first requirement the machine is provided with a flywheel of size sufficient to represent the inertia effect of the train, while, for the second requirement, the component of the train weight acting down the inclination forms a tractive effort, which in the testing machine is represented by the torque of an electric motor driving a wheel upon which shoes to be tested are mounted.

The machine, designed by Monsieur Guillery and made by the Etablissements Malicet et Blin, consists of a wheel with a diameter of 105 centimetres—the usual size for wagon wheels—braked by two shoes diametrically placed. It is supposed that the maximum loading of such a wheel is 10 metric tons, for which the corresponding inertia is supplied by a flywheel two metres in diameter and weighing 27·5 tons, turning at the same angular velocity as the wheels of a train which is moving with a given linear velocity, ranging up to 150 kiloms. per hour. The braking efficiency on the machine can reach 100 per cent.; in this case the maximum effort is 10 tons, or 5 tons per shoe, but for this maximum effort a corresponding speed of 60 kiloms. per hour cannot be exceeded because of the limited output of the driving motor. This motor, a three-phase machine, has a maximum output of 350 B.H.P.; it is arranged to drive the wheel at various speeds through a gear-box provided with six speed changes and direct drive.

Readings can be made which give for each test the instantaneous peripheral velocity, the radial force applied to the brake shoes and the tangential force resulting therefrom. In order to maintain the radial force at a constant value and in a fixed direction, passing through the centre of the wheel, each shoe is pushed against the wheel tyre by a spherical piston which slides without friction in a cylinder. The cylinder is fed with oil at a constant pressure by means of an electrically driven pump fitted with a relief valve in the pressure line.

Pistons for the measurement of the tangential force are designed on the same principle, and, moreover, are arranged so that they resist any tendency of the brake shoe to move tangentially, so that the force exerted by the shoe always passes through the centre of the wheel. Quite a small departure of the line of action of the force is sufficient to produce a considerable error. A very neat arrangement, designed by Monsieur Guillery, ensures this condition being fulfilled. It comprises a small hollow balanced valve, attached to the piston, which slides within a sleeve fixed to the cylinder. Around the sleeve acts the oil pressure set up by the pump. If the piston tends to move downwards, say, it moves with it the valve, uncovering ports in the sleeve, and oil passes above the piston to return it to its original position; and vice versa.

The pressures within the cylinders used for the determination of the radial and tangential forces are measured continuously by Guillery manometers and are balanced directly by springs—a system which lends itself admirably to graphical recording. By this method the time and the number of revolutions of the wheel are recorded and hence the energy dissipated by the wheel brakes can be deduced between any two points on the chart. In addition, by means of thermo-electric couples, the temperatures of various points in the brake shoes can be measured.

The Late Mr. E. E. Sidwell.—It is with much regret that we have to record the death of Mr. E. E. Sidwell which took place at his home on Friday, April 5th, after a sudden illness. Mr. Sidwell was a director of Bretts Patent Lifter Company, Ltd., of Coventry.

Rail and Road

ROAD ACCIDENTS.—A return of the Ministry of Transport shows that the number of persons reported to have died in Great Britain during the month of March, 1940, as a result of road accidents, totalled 496 compared with 487 during March last year.

NEW L.M.S. STATION.—A new station for passengers and goods traffic has been opened at Hillington by the London, Midland, and Scottish Railway Company. The old station has been renamed Hillington East. Train services run from Glasgow and Paisley to the new station which has been built principally to serve the factories in the Scottish Industrial Estates.

LARGE TUNNELLING SHIELDS.—Four large tunnelling shields, each weighing about 190 tons, have been built for the construction of a new subway in Chicago. These shields are 25ft. in diameter and have a length of 19ft. A cutting edge which protrudes out 4ft. in front of the top half of each shield cuts into the soil as the shield is forced forwards by 24 jacks each capable of exerting 200 tons.

STEEL FOR PRODUCER GAS PLANTS.—Manufacturers requiring steel for the production of producer gas plants for use on road vehicles for civilian use in this country should now apply to the Ministry of Transport for the necessary forms of application. All communications should be addressed to:—The Secretary, Ministry of Transport (Room 349), Metropole Buildings, Northumberland Avenue, London, W.C.2.

PRICE OF PRODUCER GAS FUEL.—It was stated by the Minister of Mines in the House of Commons recently that producer gas fuel manufactured by two firms is being supplied to consumers at a uniform price of 90s. per ton anywhere in the country. Discussions were proceeding with a third company with a view to fixing the same price for its products. Where specially dried fuel was supplied the price might be increased by 7s. 6d. per ton.

COMMERCIAL VEHICLE FUEL IN GERMANY.—It is reported that a decree of the German Minister of Transport orders that all commercial vehicles are to be converted to the use of gaseous fuel. The network of supply stations is to be extended to cover the whole country as a considerable amount of gas is now available from the number of new coal treatment and hydrogenation plants which have been erected. Official standard gas containers and feed valves were introduced in the country last year. Under the decree lorries for loads of 5 tons and over are to be converted first, starting with those which work from depots not more than 50 km. from the nearest gas-filling station. Medium-capacity vehicles will then follow, and lastly vehicles down to 1·5 tons. For the moment no conversion of private motor-cars is contemplated.

AMERICAN RAILWAY LOCOMOTIVE REQUIREMENTS.—Following an extensive study of railway conditions in the United States, Mr. R. S. Binkerd considers that although the total tractive force of the locomotives in service is still in excess of current requirements many of the engines are not suitable for the intensive operation which has been developed. In an article in the *Atlantic Monthly*, Mr. Binkerd says that of the country's reserve of freight locomotives the majority have small driving wheels which are not consistent with the high speeds of to-day. The same situation holds in boiler horsepower. Haulage of heavy trains hour after hour at the speeds of to-day calls for high sustained boiler horsepower. The older locomotives can still cope with service on branch lines and on main lines where trainloads are small; but for heavy, high-speed freight movements there is a real need for at least 1000 modern high-speed steam freight locomotives. If traffic continues to grow this need may soon become 2000 or even 3000 such locomotives, largely of the 4–8–4 type.

SOIL STABILISATION BY HEAT TREATMENT.—A note in the road abstracts compiled by the Department of Scientific and Industrial Research and the Ministry of Transport deals with an article by G. W. Eckert on soil stabilisation by heat treatment. It is suggested that a travelling furnace capable of handling large amounts of soil at temperatures over 500 deg. Cent. may solve the problem of low-cost construction in areas where heavy clay soils exist and where no type of rock or aggregate is available. The action of heat on the physical and chemical properties of different types of clay soils is described. It is considered that in order to obtain aggregate of the greatest strength and water resistance, the soil should be heated to the highest temperature and for the longest time compatible with furnace capacity and fuel cost. Laboratory investigations of the soil samples should include mechanical analysis; determination of dehydration temperature; effect of time and temperature of heating; and, in certain cases, the use of fluxes for enhancing vitrification, and the use of bituminous materials for binding the heated soil aggregate.

TUBE TRAINS TO HIGH BARNET.—The second extension of London's underground railways since the war was opened on Sunday, April 14th, when Northern Line tube trains began to run beyond East Finchley over the 5¼ miles of newly electrified London and North-Eastern Railway tracks to High Barnet, thus providing the first direct railway link between High Barnet and the West End. High Barnet is 12 miles from Charing Cross and tube trains will run between Morden and High Barnet, a distance of 23 miles. The extension has been undertaken jointly by the London and North-Eastern Railway and the London Passenger Transport Board and is part of the £40,000,000 programme of extensions and new works in the London Transport area. The line from Finchley Central to High Barnet was opened almost exactly 68 years ago—on April 1st, 1872. Electrification enables a greatly increased train service at regular intervals to be given. In peak hours there is a train every 10 minutes from High Barnet and one every 5 minutes from Finchley Central (formerly called Finchley, Church End). In the slack hours there are trains every 12 minutes from High Barnet and every 6 minutes from Finchley Central. The first part of the programme for improving the railway services in North London was completed on July 9th, 1939, when the Northern Line of London Transport and the L.N.E.R. tracks to High Barnet and Edgware were linked by two miles of new tunnel between Archway and East Finchley.

Miscellanea

A WIRELESS MEMORIAL.—The position occupied by the first permanent wireless station at Alum Bay on the Isle of Wight has been marked by the erection of a memorial in grey Cornish granite. It was here, after a few experiments elsewhere, that in 1897 Gugliemo Marconi and other engineers carried out experiments which led to the s anning of the Atlantic by wireless from Poldhu in 1901.

PRESENTATION OF FARADAY MEDAL.—The Faraday Medal will be presented to Dr. Alexander Russell at the ordinary meeting of the Institution of Electrical Engineers to be held on Thursday, April 25th, 1940, at 6 p.m. The presentation will precede the thirty-first Kelvin lecture, which will be delivered by Dr. C. G. Darwin on "Thermodynamics and the Coldest Temperatures."

THE ELECTRIC SUPPLY INDUSTRY.—At the recent Electricity Supply Sales Management Conference held by the British Electrical Development Association, Mr. J. B. Ashworth pointed out the importance of the electric supply industry to the economic life of this country. He drew attention to the fact that it gave direct employment to about 103,000 employees with an annual wages bill of nearly 16 million pounds, and indirect employment to a further 40,000 workers. It had a total capital of over 608 million pounds, the annual revenue being 91 million pounds.

BOARD OF TRADE ANNOUNCEMENT.—In view of the uncertainties in the military and political situation at present existing with regard to Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Sweden, and Russian ports on the Baltic and Arctic Seas, the Board of Trade has made an Order, which comes into force immediately, prohibiting the exportation, except under licence, of all goods from the United Kingdom to those destinations. All outstanding licences for exports to these destinations have been revoked. The Order does not apply to Iceland, Greenland, and the Faroe Islands.

CHANGES AT THE N.P.L.—A new Department of Light has been formed at the National Physical Laboratory, to comprise the former Optics Division of the Physics Department and the Photometry Division of the Electricity Department. Mr. T. Smith, F.R.S., has been appointed superintendent of the new department as from April 1st, 1940. Dr. E. H. Rayner retired from the post of Superintendent of the Electricity Department on March 31st, 1940, having attained the normal age limit. He has been succeeded by Mr. R. S. J. Spilsbury, formerly Principal Scientific Officer in the department.

TELLURIUM IN TIN ALLOYS.—It was shown by Dr. Hanson and Dr. Pell-Walpole some time ago that a little tellurium improves the creep strength of pure tin, both in the rolled and the cast conditions. A convenient method of determining tellurium in these alloys has been worked out by Dr. Pell-Walpole. He ascertains the loss of weight that occurs on distillation *in vacuo* when tin telluride distils without dissociation. Particulars of the method are given in Publication 96 of the International Tin Research and Development Council, and copies may be obtained upon application to the offices at Fraser Road, Greenford, Middlesex.

THE HOGSMILL VALLEY DRAINAGE SYSTEM.—It is expected that an early start will be made on the £440,000 Hogsmill Valley drainage scheme. Kingston, Surbiton, Malden and Coombe, Epsom and Ewell Town Councils are jointly concerned in the scheme, under which ultimately two sewage works in Epsom and Ewell district and Kingston's sewage works near Canbury Gardens will be done away with, and those of Surbiton and Malden, which adjoin, will be combined and will treat the sewage from the four boroughs. The area covered by the scheme is approximately 17,254 acres, with a population in 1936 of 169,500 and an estimated potential population of 402,500.

HIGH-VOLTAGE CABLE INSPECTION.—In order to determine whether the conductors of high-voltage cables are properly centred, an X-ray viewing machine has been installed by an American Company, the Simplex Wire and Cable Company. According to the *Electrical Review* it comprises an X-ray outfit through which the cable passes as it leaves the machine that applies the insulation. An operator sits watching two fluoroscopic screens, which present views of the cable interior at 90 deg. planes. When a doubtful section of cable is observed, the operator presses a switch that exposes two X-ray films, at the same time marking the particular cable section so that it can be rejected if the photographs confirm the visual observation that the conductors are too far from the centre.

INDUSTRIAL DEVELOPMENTS IN ITALY.—The special correspondent of the *Chemical Trade Journal and Chemical Engineer* in Rome reports that some twenty million lire is to be spent on extensions to the laboratory at Novara of the "Montecatini" Societa Generale per l'Industria Mineraria e Chemica. A new works is also being erected for the recovery of vanadium oxide from bauxite. This plant, which is said to be the first of its type in the world's aluminium industry, will enable Italy to cover about a third of its national needs in vanadium oxide. The possibilities of utilising the red mud produced in aluminium manufacture in the manufacture of steel in the electric furnace is under investigation, with results that are highly promising. With the object of furthering the manufacture and use of the light metals in Italy, the Montecatini company, in collaboration with other interests, has formed the Istituto Sperimentale dei Metalli Leggheri.

ENGINEERING STUDENTS AND NATIONAL SERVICE.—According to the new schedule of reserved occupations, student engineering apprentices or learners are now reserved at the age of 18. This relates, however, only to a man employed in industry or under articles to a professional engineer who is certified by a University or technical Institution or by a professional Institution of Engineers as within two years of the satisfactory completion of a course of study with a view to offering himself for the first time for an engineering degree; an engineering Higher National Certificate; the Associate Membership of the Institution of Civil, Mechanical, or Electrical Engineers, or the Associate Fellowship of the Royal Aeronautical Society; or an examination of similar standing to that of an engineering degree. These amendments are not retrospective in their effect, that is they do not involve the release of men now in the Forces or of men who have already received enlistment notices.

Air and Water

AN AIR MINISTRY APPOINTMENT.—The Air Ministry announces that Sir Samuel Hoare has appointed Lieut.-Col. J. T. C. Moore-Brabazon to be his Parliamentary private secretary at the Air Ministry.

THE "QUEEN ELIZABETH."—Replying to a question in the House of Commons recently, the Minister of Shipping said that the "Queen Elizabeth" had been sent to the United States for more than one reason, but there was no question of her being transferred to another flag.

NEW LONDON TO LISBON AIR SERVICE.—On Monday, April 8th, a British Overseas Airways Corporation air liner left Heston on the first of three preliminary flights inaugurating a new London–Lisbon air service. This new service will link up with the Pan American Airways' North Atlantic route and thus give a service between London and the United States.

AMERICAN AIRCRAFT FOR SOUTH AFRICA.—An order has been placed in the United States for sixteen twin-engined Lockheed machines at a reported cost of £25,500 each by South African Airways. These machines, which are fitted with Pratt and Whitney engines, have a top speed of 262 m.p.h., and carry fourteen passengers each. The purchase is also being considered of two four-engined machines with a seating capacity for thirty-two passengers, and having a speed of 296 m.p.h.

SHIPPING LOSSES.—During the week ended April 8th, one British merchant ship of 208 tons and one Norwegian ship of 2118 tons were lost as a result of enemy action. Up to noon on Wednesday, April 3rd, 15,751 British, allied, and neutral ships had been escorted in British convoys with a loss of 29 ships, being a loss ratio of one in 543. The ships lost up to that date were 25 British, 1 allied, and 3 neutrals. The number of neutral ships convoyed was 2446, and the number lost, one in 815.

THE LATE FLYING OFFICER N. S. GRAEME.—We regret to have to record that Flying Officer Nigel Stuart Graeme, who had been assistant sales representative in Scotland for British Timken, Ltd., from September, 1938, until the outbreak of war, has been killed in an aircraft accident in France. Flying Officer Graeme was the son of Colonel and Mrs. F. A. Graeme of Farnborough, Hants. He joined British Timken, Ltd., in 1937, and passed through the works and the technical department before taking up his position in Scotland.

STANDARD BUILDINGS FOR CANADIAN AIRPORTS.—In connection with the airports being constructed in Canada, under the Empire air training scheme, standard designs have been prepared for the buildings and hangars. Forty such designs have been prepared and they embrace every type of structure for air force stations, schools, or depots. Timber hangars having a span of 112ft. and a depth of 126ft. have been designed for rapid erection and for easy removal to other sites, the only permanent feature about them being the paved floor. All the timber used in the buildings will be chemically treated to make it fire-proof.

THE "HAMPDEN" BOMBER.—Since the beginning of the war some particularly good work has been done by the Handley Page "Hampden" type medium bomber. These machines are all metal, mid-wing monoplanes, having a capacity for carrying large loads long distances at high speeds. They each have two Bristol "Pegasus" engines of about 1000 H.P. which give a cruising speed of about 220 m.p.h. and a maximum speed of 265 m.p.h. The machines have a wing span of just over 69ft., their overall length being 53ft. Of their "all up" weight of 8½ tons over 3 tons is useful load, and a crew of three or four is usually carried.

THE SPEED OF AEROPLANES.—Some interesting forcasts with regard to the speed of aircraft in the future, made by Messrs. F. Flader and E. R. Child at a meeting of the American Institute of Aeronautical Science, are given in *The Times*. It was suggested that within the next five years aeroplanes will be capable of a speed of over 500 miles an hour. In the opinion of these two engineers drag can be reduced by attention to such things as cockpit enclosures, landing gear, exhaust pipes, and engine cooling methods. They considered that liquid-cooled engines were superior to air-cooled ones for speed purposes and suggested that they might be mounted in a central fuselage and arranged to drive outboard pusher propellers.

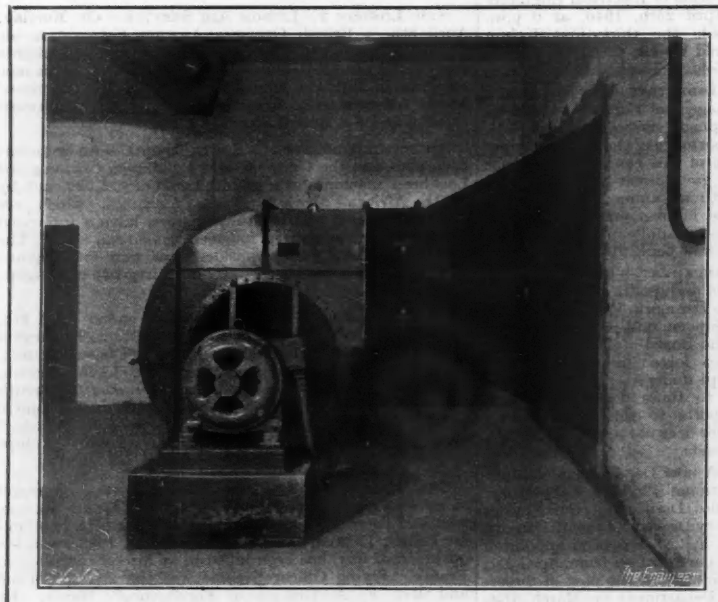
THE UNITED MOLASSES COMPANY'S FLEET.—It is shown in the annual report of the United Molasses Company, Ltd., that it took delivery of a new motor tanker of 15,300 tons deadweight in September last and a second tanker of 10,500 tons launched on the company's account in January has since been completed and is now in commission. The company has not lost any ships as a result of the war and it now has twenty tankers of an average age of nine years and five of ages varying between eight and twenty-one years. A third new tanker is being built in Italy at a cost of about £245,000. On January 1st, the company transferred 20 motor tankers, five tank steamers, and two barges to a newly-formed wholly-owned subsidiary company, Athel Line, Ltd. This transfer was effected for the purpose of simplifying the operations of the fleet during war conditions.

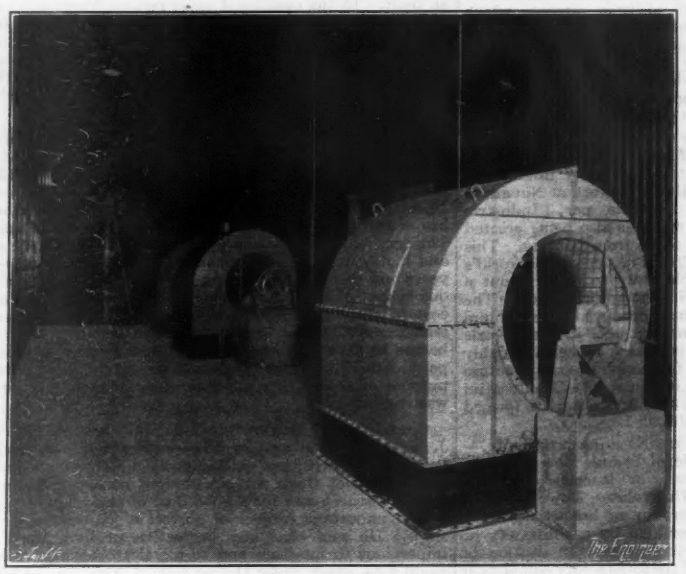
CORROSION ON BOARD SHIP.—It was concluded by Dr. J. H. Paterson, in a paper on corrosion in ship structures before the Institution of Engineers and Shipbuilders in Scotland, that there was an obvious necessity for more special research and for a good deal of exchange of views in the important subject of corrosion with reference to ships. He said that any protective medium must be impervious to moisture and to oxygen, otherwise rusting could take place under the protective coat. Solid fillers contained in most protective media must not be capable of attack from any external source, otherwise the continuity of the protective surface might be destroyed and corrosion would go on as though the medium were not present. He said that it had been found on several occasions, for instance, that when lime compounds had been used as fillers in tank top compositions, liquid condensates from the cargo or from the coal bunkers had been slightly acid in character, and the composition had gradually deteriorated and allowed corrosion to take place underneath it.

VENTILATION PLANT FOR ROLLING MILL ELECTRICAL MACHINERY

THE VISCO ENGINEERING CO., LIMITED, CROYDON, ENGINEERS

(*For description see page* 380)





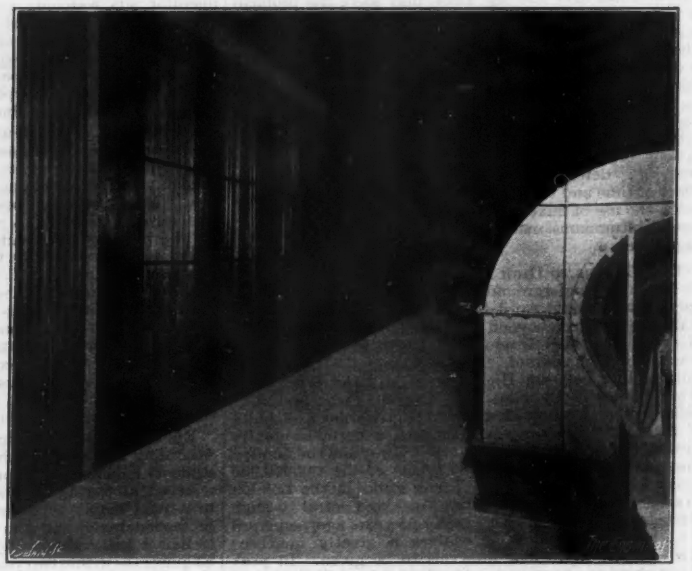


FIG. 1—FANS FOR HOT STRIP MILL MOTORS

FIG. 2—DRY CELL FILTER

FIG. 3—MAKE-UP FAN

FIG. 4—AIR COOLERS

FIG. 5—FANS FOR COLD MILL MACHINERY

FIG. 6—SELF CLEANING FILTERS

Pencil Portrait No. 24

SIR JOHN E. THORNYCROFT, K.B.E.

DRAWN FOR THE ENGINEER BY ELLIOTT & FRY

UNIV. OF MICH.

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The Engineer

APRIL 19, 1940

VOL. CLXIX No. 4397

Contents

THE ENGINEER, April 19th, 1940 PAGE

A SEVEN-DAY JOURNAL ... 365

LEADING ARTICLES—
A Hydrogenation Fallacy ... 377
The Export Drive ... 377

SPECIAL ARTICLES—
Acceptance Test Charts for Machine Tools ... 371
Scientific Instruments and Apparatus. No. IV. (Illus.) 368
Turbine Locomotive Experiences. No. I. (Illus.) ... 366

Automatic Supervisory Control for a Pumping Scheme. (Illus.) ... 385
Canadian Hydro-Electric Developments ... 374
Development in Design of Boilers and Boiler House Auxiliaries. (Illus.) ... 381
Direct-Coupled Roller Motors. (Illus.) ... 372
Forging Manipulator. (Illus.) ... 383
Hot Air Power Plant. (Illus.) ... 373
Liquid Level Alarm. (Illus.) ... 385
Lorry Mounted Air Compressor. (Illus.) ... 383
New Gear Tooth Hardening Machine. (Illus.) ... 384
Provision of Engine Power on South African Railways 371
Pulverised Coal for Steel Furnaces ... 380
Railway Brake Testing Machine ... 374
Ventilation of Electrical Machinery at a Steel Rolling Mill. (Illus.) ... 380
Water Circulation Indicator. (Illus.) ... 384

LETTERS TO THE EDITOR—
A Problem in the Philosophy of Mathematics ... 378
Vortex Casing for an Experimental Fan ... 379
Strength of Beams ... 379

LITERATURE ... 378
Books Received ... 378
Short Notices ... 378

NEWS AND NOTES—
Air and Water ... 375
British Patent Specifications. (Illus.) ... 387
British Standards Institution ... 385
Catalogues ... 388
Forthcoming Engagements ... 388
French Engineering Notes ... 387
Markets, Notes and News ... 386
Miscellanea ... 375
Personal and Business Announcements ... 388
Rail and Road ... 375
Sixty Years Ago ... 379

NOTICES TO READERS

WAR MEASURES

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GENERAL

The head office, 28, ESSEX STREET, STRAND, W.C.2, is open from Mondays to Fridays inclusive from 9-15 a.m. to 5-15 p.m., where classified advertisements may be handed in as usual and copies of the paper may be purchased. The office is not open on Saturdays.

PAPER SUPPLIES

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**** If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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**** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGE OF ADDRESS

**** Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Postal Address: "The Engineer," 28, Essex Street, Strand, London, W.C.2.

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Pencil Portrait No. 24

With this issue we present a Pencil Portrait of Sir John E. Thornycroft, K.B.E., Managing Director of J. I. Thornycroft and Co., Ltd., and a Director of the Southern Railway Company. Sir John is a Member of Council of the Institution of Civil Engineers, a Past-President of the Institution of Mechanical Engineers, and a Vice-President of the Institution of Naval Architects.

A HYDROGENATION FALLACY

IF the whole of our present annual output of coal—some 260 million tons—were converted into oil by one or other of the known hydrogenation processes it would give us 47 million tons of oil per annum, or three and a half times more than we require. We could, in fact, heat and light the population through a pipe-line and have a large surplus for export. We take these words, substantially verbatim, from Mr. F. Heron Rogers' recent presidential address to the Institution of Chemical Engineers. Mr. Rogers has a firm faith in the future of "oil from coal." While he appears to be somewhat sceptical about the commercial applicability of the high-pressure Bergius process of converting solid coal directly into oil—the process in use at the I.C.I. Billingham plant—he seems to feel assured of the ultimate success on a large scale of the low-pressure, low-temperature Fischer-Tropsch process of obtaining oil by uniting hydrogen with the products of combustion of coal, carbon monoxide and dioxide. In 1938 the imports into this country of petroleum, petrol, fuel, lubricating, and other mineral oils were valued at nearly forty-two and a half million pounds. Economists assert that this money creates a trading reserve of sterling abroad which sooner or later returns to us to be cashed for British goods. Mr. Rogers accepts that argument as being, in the main sound, but, he says, it is only partially true; a good part of the money returns to us in the form of American investments in our industries. It would certainly be preferable if from our own natural resources we could make ourselves independent of overseas oil supplies and had even an exportable surplus. We may express our full agreement with Mr. Rogers in this fond wish. But when he asks us to believe that this country is undoubtedly in a position to realise that wish we must beg him to reconsider the facts and figures on which he bases his conclusion.

The first sentence of this article not only summarises Mr. Rogers' argument but, in what it says and in what it leaves unsaid, provides all that is required to demonstrate that his argument is unsound. In 1938 the United Kingdom imported and retained for its own use 11½ million tons of mineral oil and oil products. In addition we produced from our mines 260 million tons of coal of which we exported about 50 million tons. Our home requirements of fuel were therefore 11½ million tons of oil and 210 million tons of coal. Mr. Rogers would take the whole of our coal output—260 million tons—and convert it into 47 million tons of oil. That quantity of oil would enable us to dispense with our annual importation—11½ million tons—and leave us with a surplus of 35½ million tons. The first thing to do with that surplus would be not to export it, but to use it in part compensation for the home-mined coal which would no longer be available as such. The calorific value of oil being on the average not much more than one and a third times the calorific value of coal, this surplus of 35½ million tons of oil would be equivalent in heating capacity to about 48 million tons of coal. Hence to make good our own home requirements of 210 million tons it would be necessary to mine an additional 162 million tons of coal per annum. Even so we would still not be in a position to "heat and light the population through a pipe-line" because the extra 162 million tons would have to be burned as coal and not be converted first into oil. On this basis our annual output would have to be raised from 260 to 422 million tons or to 472 million tons if we wished to retain our coal export trade at its existing level. To convert the country to an "all-oil" basis, relying entirely on our own resources, our mines would have to be taxed still further. Our 1938 home requirements of 11½ million tons of oil and 210 million tons of coal are, on a heating value basis, equivalent to 169 million tons of oil. To produce that quantity of oil by the hydrogenation process would, on Mr. Rogers' own showing, require an annual output of 935 million tons of coal. And still there would be no surplus whatever for export. In 1938 we exported about one-fifth of our total output of coal. If we sought to export the same proportion of our total oil production we would require to draw upon our coal resources at the rate of about 1170 million tons a year or four and a half times as liberally as we do at present. No one giving a thought to the future will view such a possibility with a calm mind.

There are a number of other implications involved in Mr. Rogers' scheme which, if the considerations mentioned above are by any chance found insufficient to condemn it as unsound, may be advanced to reinforce that conclusion. The question of price is clearly all-important. In 1938 according to Board of Trade figures the declared value of imported fuel oil averaged 2·3 pence per gallon. In Germany it was claimed at about the same date that by means of the Fischer-Tropsch process equivalent oil was being produced at a cost of 8·25 pence per gallon. Since then the cost is said to have been reduced to 6 pence per gallon. Even so it is evident that this hydrogenation process has still a very long road to travel before it can produce oil at a cost competitive with that at which we can import it from natural sources of supply. The Bergius process would seem to be even in worse case as regards cost of production. Other objections to the scheme will no doubt occur to our readers. However we view it we always come back to the fact that the hydrogenation of coal by any process so far tried, or by any process which conceivably may be suggested, is, and must be, highly wasteful of the heat units stored in our coal measures. At present about 5½ tons of raw coal are required to produce one ton of fuel oil, a figure which, even allowing for the slightly higher heating value of the oil, indicates the extremely poor thermal efficiency of the hydrogenation process. It is possible that with time the economy of the process might be improved, but even if we suppose that its efficiency could be doubled it would still remain thermally wasteful. It must be realised that any process involving the application of heat to coal, whether in coke ovens, gas works, low temperature distillation plants, or in hydrogenation chambers, is thermally wasteful and can only be tolerated if it yields products more convenient or more valuable than the raw coal before treatment. It has been satisfactorily established that the treatment of coal in plants of any of these types except the last named is within, or well within, the toleration limit. Mr. Rogers has demonstrated, although he presumably did not mean to do so, that the hydrogenation process lies, and is likely to continue to lie, beyond that limit. We may express our gratitude to him for the demonstration; it is comforting at the present moment to reflect that it is the Germans and not we who have chosen, or been forced to rely on, the hydrogenation process as a material source of oil supply.

The Export Drive

"EXPORT Groups in War Time" was the subject of an address by Sir Clive Baillieu at the monthly luncheon meeting of the British Engineers' Association on April 11th. So topical a subject naturally drew a large attendance of representatives of engineering firms from all over the country. The problem of carrying on an export business in wartime probably presents more difficulties to the engineering industry than to most others. The productive capacity of most engineering concerns is largely taken up with war work, whilst the most important of the industry's raw materials are iron and steel in one form or another, and when there is an inordinate demand it has to compete for its raw materials with many other important industries, such as shipbuilding and transport. At the same time it is obvious that the nation

can afford to lose its valuable export trade in machinery and similar products even less in war-time than during peace. Engineers, therefore, must feel that they are squeezed both in the matter of supplies of raw material and in the portion of their output which they are allowed to export; and any indication as to how they could meet this problem was naturally eagerly welcomed. Sir Clive Baillieu dealt first with the raw material side, and acknowledged the difficulties of finding adequate supplies to increase production sufficiently to meet both the home and export demand. In fact he grouped together several important factors, raw materials, labour, shipping, and plant capacity. As a member of the Executive Committee of the Export Council, he promised the engineering industry the help of that body in providing practical advice upon the problems which faced it. In the matter of raw materials, the new system of steel distribution should, he said, help, as by this it was hoped that consumers of iron and steel would know precisely what they would receive against their contracts and the time of delivery, instead of being, as hitherto, entirely at sea on these important factors. So complicated a scheme could not be expected to be put immediately into effect, but already the iron and steel trade and important consumers, like the engineers, were settling down to work out the application of its provisions, which promise a more suitable and regular system of distribution than was possible under the old method of licensing.

In the course of one short address it was impossible to deal in detail with all the difficulties of the "export drive." It is, of course, common knowledge that groups of manufacturers and merchants are being formed to co-ordinate the effort to expand the country's export trade. The composition of the groups, for instance, might present some problems, but Sir Clive Baillieu pointed out that there was no rigid rule regarding the elements of which these bodies would be constituted. One of the functions of the Export Council was to co-operate and help exporters. For instance, if a firm found it difficult to place an order for the required delivery the Council might be able to find a supplier. It could also help in matters affecting insurance, shipping, and packing. Such difficulties, however, should first be brought before the groups concerned and only if they could not be overcome should they be referred to the Export Council. One of the greatest obstacles with which the exporter is confronted at the present time is the impossibility of obtaining firm quotations and definite delivery dates. Sir Clive Baillieu pointed out that the new steel distribution scheme was designed in part to overcome this trouble in that industry. The necessity to maintain the export trade during the war needs no stressing, and Sir Clive emphasised the duties of the Export Council when he said that if that organisation did not get the maximum exchange gain from the exports it was not doing its job. Although no mention was made of this aspect of the drive it is understood that efforts will be concentrated upon exporting the more highly finished, and therefore the more expensive, products, rather than raw materials or articles of a semi-finished character which would have to be worked up to the finished forms in foreign countries. This indicates that efforts will be directed to provide the engineering industry with the finished forms of iron and steel which are its raw material, instead of exporting those materials as iron and steel, although to the steelmaker they would be the finished articles. This may mean that some industries will suffer a contraction of their export trade for the national good in order that the more expensive products may be sent overseas.

If we turn to the last war, some interesting statistics are obtainable from the Board of Trade Returns which were published after the conclusion of hostilities. Taking the four years 1915–18, inclusive, we imported 638,417 tons of pig iron, the chief suppliers being Sweden and the United States; but we actually exported 2,745,521 tons. These figures perhaps do not give a very true picture of the position, since the exports were almost entirely to British Empire and Allied countries. Apparently, the imports of blooms, billets, slabs, and sheet and tinplate bars during those four years reached the moderate tonnage of 668,115 tons, and our imports of finished steel in the shape of bars, angles, girders, beams, and joists the still smaller tonnage of 277,279 tons. On the export side, however, we actually managed to export 345,243 tons of ingots, blooms, billets, slabs, and sheet and tinplate bars, and of finished steel in the form of bars, angles, rods, and sections no less than 1,695,647 tons, although of the latter quantity 1,349,534 tons went to France. It would thus seem that in the last war in spite of the intense pressure upon our steel production, and the fact that the output of both pig iron and steel was less than ten million tons a year, we were able to spare by comparison a fair proportion for export. It will be remembered that our exchange at the end of the last war was in a far from satisfactory condition, and it is to save us from a repetition of that experience that the export drive has been initiated. Whether it will be possible greatly to expand our exports remains to be seen, since it must in the first instance depend upon the overseas buyer. At the beginning of this war there was a rush in almost every country of the world to obtain British iron and steel materials and machinery, but the experience of many firms lately is that this demand has now died down. More than one reason may be adduced for this decline in export business, one being the desire of all neutral countries to maintain their exchange by curtailing their expenditure upon foreign goods. The difficulty of avoiding the supplying of countries which might merely provide a channel for British exports to Germany is also of vital importance, and this presents one aspect of the problem which we cannot afford to lose sight of, even if it means the loss of valuable export orders.

Literature

SHORT NOTICES

Le Calcul des Constructions Soudées. By J. Vandeperre and Artemy Joukoff. Brussels. Albert de Boeck.—This work by two Professors of Brussels University is a real contribution to the literature dealing with welded construction. The results of the experiments detailed in the book cover a large programme of research carried out at the above-mentioned university. The contents deal with electric arc welding, electric resistance welding, and the lesser known process of atomic hydrogen welding. The subjects include welded joints, welded design, welding procedure, and the testing of finished welds. Suitable illustrations including photographs and sketches as well as numerous mathematical calculations make the work of great interest to all students of welding. In order to make this valuable book available to a larger circle of readers in this country, an edition in the English language might well be undertaken.

BOOKS RECEIVED

Calvert's Mechanics' Year Book. Timperley: Sherratt and Hughes, Saint Ann's Press. Price 6d. net.

Aircraft Identification. Third Edition. London: "The Aeroplane," Bowling Green Lane, E.C.1. Price 1s. 6d. net.

Brazing: Principles, Materials, and Methods. London: Emmott and Co., Ltd., 28, Bedford Street, W.C.2. Price 1s. net.

Rhodesian Mining Year Book, 1940. London: Argus South African Newspapers, Ltd., 85, Fleet Street, E.C.4. Price 12s. net.

Industrial Plastics. By H. R. Simonds. London: Sir Isaac Pitman and Sons, Ltd., Parket Street, W.C.2. Price 22s. 6d. net.

The Water Engineers Handbook and Directory, 1940. London: "Water and Water Engineering," 30, Furnival Street, E.C.4. Price 8s. 6d. net.

Specification, 1940. By F. R. S. York, A.R.I.B.A. London: Architectural Press, Ltd., 45, The Avenue, Cheam, Surrey. Price 10s. 6d. net.

Design and Construction of Air Raid Shelters. By D. H. Lee, B.Sc. London: Concrete Publications, Ltd., 14, Dartmouth Street, S.W.1. Price 8s. 6d. net.

First Year Engineering Science. By G. W. Bird, B.Sc. Revised by B. J. Tams. London: Sir Isaac Pitman and Sons, Ltd., Parket Street, W.C.2. Price 5s. net.

Quantitative Spectrographic Analysis with the Microphotometer. Part 1. London: British Non-Ferrous Metals Research Association, Euston Street, N.W.1. Price 2s. net.

A History of the Great North of Scotland Railway. By Sir Malcolm Barclay-Harvey, K.C.M.G. London: Locomotive Publishing Company, Ltd., 3, Amen Corner, E.C.4. Price 10s. net.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A PROBLEM IN THE PHILOSOPHY OF MATHEMATICS

Sir,—Just a line of appreciation for your thought-provoking second editorial of April 5th, *re* the damping coefficient term of the vibrational equation.

I cannot recall where I once saw the equation with the *square* of the middle term solved, but it was immensely complicated and lengthy. Your other suggestions are very ingenious; but since the effects lumped together under the general name of "damping" are so varied (inertial, viscous, vorticial, capillary, radiative, &c.) each case really has to be dealt with backwards by measuring the effect and constructing the function by the methods of finite differences (or in practice by a good deal of smoothing).

Your further penetrating remarks are valuable in both pure and applied mathematics. For instance, what is a function? Will Y be a *practicable* function of X if it requires a billion terms and an acre of paper to write them? Also the question as to what really we mean by "mathematics" (1) what we wish to express by any means at our disposal, (2) or what we can express on our two-dimensioned paper and limited powers of calculation with comparatively few symbols, *i.e.* the criterion of simplicity which eventually controls everything we do.

John L. Dunk.

Folkestone, April 8th, 1940.

[A step-by-step process of solving the equation $\ddot{x}+2b(\dot{x})^2+a^2x=0$ will be found in "Technische Schwingungslehre" by Dr. Wilhelm Hort, published by Julius Springer, Berlin. The process is not very lengthy or unduly complicated. It yields directly an expression for the amplitude at the end of each swing, the calculation of the amplitude reached at the end of any one swing being based on the previous calculation of the amplitude at the end of the preceding swing. The sign of the coefficient b is changed alternately from plus to minus with each swing.—Ed. The E.]

Sir,—With reference to your article in the issue of April 5th, entitled "A Problem in the Philosophy of Mathematics," we should like to draw attention to several statements quoted by the author which seem to us not only to be inaccurate, but seriously to undermine the logical foundation on which the article is based.

First. The assertion that "the true period of a simple pendulum is T×F, where F is a factor which no mathematician has yet succeeded in expressing completely with the aid of a finite number of symbols." To see that this is a mis-statement of fact we have only to quote the well known result that F is equal to $\frac{2}{\pi}$ K, where K is Legendre's complete elliptic integral of the first kind, to modulus $\sin \alpha/2$ α (being the angular amplitude of the oscillation, not assumed small) and which incidentally reduces to $\pi/2$, as α tends to zero. Since Legendre's time, well over a hundred years ago, K has been as much a part of the mathematician's repertoire as the sine, cosine, or logarithm and its values are to be found in any complete book of tables.

What the author presumably intended to convey is that F is not expressible in finite terms as a combination of (sic) "Elementary" functions; but as the qualifying adjective is so elastic as to have altered its significance entirely, since Newton's time, we feel that any assertion of this kind is as vague as it is misleading.

Secondly. While we are prepared to substantiate the claim that the differential equation $\ddot{x}+2b(\dot{x})^2+a^2x=0$ is insoluble, we cannot accept the logic by which it is deduced that such an equation implies the existence of a negative damping factor. This implication is only justifiable on the assumption that it is necessarily possible to represent the continuous motion of a dynamical system by *one* differential equation, and this assumption is undoubtedly false. We have only to consider the motion of a particle under gravity in a medium where the resistance to motion is proportional to the first power of the velocity. If, for example, the resistance per unit mass $=k\dot{x}$, the differential equation representing the motion of the particle on its upward journey, assumed vertical is $\ddot{x}+k\dot{x}+g=0$, while on the downward journey, after its highest point has been reached, is $\ddot{x}+k\dot{x}-g=0$. This is only one of many examples which illustrate the necessity of allowing for the possibility of two (or more) such equations.

Thirdly. It does seem most unreasonable, after having acknowledged the insolubility of a second order differential equation involving $\dot{x}^2$, to suppose that one containing $\dot{x}^3$ is likely to admit of solution merely on the grounds that it appears to have a stronger physical significance.

In conclusion, may we say that in answer to the author's most interesting question, it might be more accurate to suppose that until the full powers and limitations of mathematics are known to us all, it would seem preferable to assume those limitations responsible for our apparent inability to solve certain physical problems, sooner than to attempt to alter the formulation of natural laws, so as to bring them within the scope of our present mathematical technique.

J. H. PEARCE, M.A. (Cantab.).
A. V. JACKSON.
L. R. E. KENNEDY.

Greenwich,
April 10th.

[Full comment on this interesting letter is reserved until other readers, if they so desire, have expressed their views on the points raised in it and in the leading article to which it refers. Meanwhile we would ask our correspondents to ponder the question whether everything is as it should be if the continuous motion of a dynamical system has to be represented by a discontinuous differential equation. If we are told that it is necessary to do so our immediate reaction is to examine the conditions prescribed for the motion with a view to discovering in them some element which is in disagreement with natural fact. We do not need to look far in the case of the example mentioned by our correspondents to find the flaw in it of this kind. The equation as written contradicts the truth of Newton's law of universal gravitational attraction. It should be unnecessary to insist that as the discussion involves ultimate verities no contribution to it can be of any value if it relies on easy approximations to the truth, however closely they may, in certain restricted circumstances, agree with natural fact.—ED. THE E.]

A VORTEX CASING FOR AN EXPERIMENTAL FAN

SIR,—Last summer, as part of his Carnegie research work, the writer designed and had built for his experiments a simple vortex casing of the "Thomson," or (probably more accurately) of the "Decoeur" type. The present description of the new fitting, which superseded a volute casing, may contain points of interest.

The object is to maintain uniform mean conditions of pressure and velocity round the entire periphery of the fan impeller for all values of the discharge. The air enters the impeller A—see accompanying drawing—after passing through a Venturi meter J, I which measures the flow. Taps K and L lead to a micromanometer and give the velocity head at the throat of the meter. On leaving the impeller the air flows between two flat annular vortex plates C and N on the outer peripheries of which are screwed the throttle rings E and F, which are rotated by handles G. The screw threads engaging C and F, also N and E, have a lead of $\frac{1}{10}$in., while the circumferences of E and F are divided into 100 equal parts by scribed lines, so that the clearance between the lips of the throttle rings can be set with great accuracy to control the flow. In the figure, F is shown in its extreme screwed-in position, while E appears in its extreme screwed-out position. A baffle ring H maintains uniform conditions just outside the throttle rings. Plate N is kept in position relative to C by three slender pillars D.

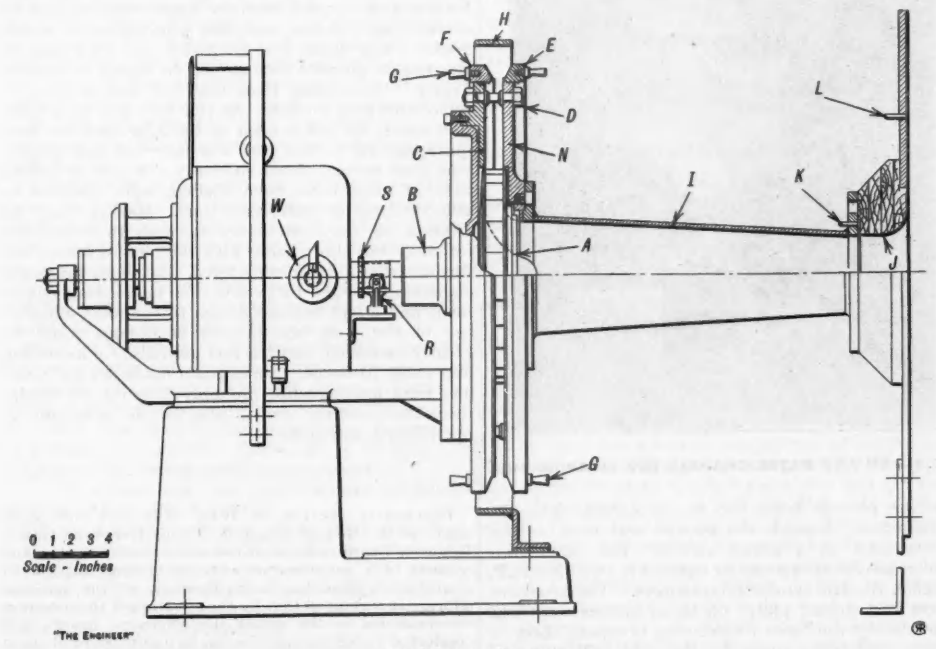
A simple casing of this kind allows certain features of the flow in the region just outside the impeller rim to be studied with the knowledge that the average conditions at the measuring station also occur at the same radius in other parts of the casing. Pitot and "yaw" tubes can therefore be introduced into the space between C and N at convenient points in order to measure dynamic pressures and flow directions. The pitot and yaw heads for this purpose are $\frac{1}{8}$in. in diameter, and have 0·0145in. diameter holes. The internal surfaces of the impeller and casing can also be artificially roughened by gluing granular materials to them.

The power input to the fan is measured by noting the torque reaction experienced by the driving motor field,* which is free to swing in trunnions of a special form. The torque is balanced by a 1·2 lb. cylindrical weight W which moves along an arm consisting of an accurately screwed rod having 10 threads per inch. The cables conveying current to the armature and field coils are light and flexible, and are led away vertically. The rotational speed of the impeller is kept steady at values of 1800, 2400, 3000, or 3600 revs. per minute, by means of the stroboscopic collar S which has 10 facets and is viewed in the flickering beam produced by a neon lamp connected to 50 cycle A.C. mains. The speed of rotation can also be obtained from the revolution counter R, which is driven by the motor shaft at $\frac{1}{10}$th of the latter's speed.

The writer hopes to carry out during the coming summer certain tests with this casing, especially with the object of measuring, if possible, the effect of the "relative roughness" of the internal surfaces on the efficiency of the fan.

G. G. MCDONALD

The James Watt Engineering Laboratories,
The University, Glasgow, W.2.
April 5th, 1940.



EXPERIMENTAL FAN

STRENGTH OF BEAMS

SIR,—Whilst much has been written on the properties of beams, it would appear that little attention has been paid to the characteristics of short beams. It is well known that the formulæ applicable to a beam of considerable length in relation to its depth are satisfactory enough for practical purposes, but when a beam is short in relation to depth, the same formulæ are inadequate and serious discrepancies occur.

Obviously, if the supports of a simply loaded beam are so close together that bending is practically eliminated, it may be justifiable to consider the shear stresses only, but in the majority of cases under consideration there are both bending and shearing stresses. Over a series of tests taken on simply loaded pins, having lengths in the region of three times their depths, we found that the actual breaking stress may be as high as double the calculated ultimate strength. The National Physical Laboratory has investigated the strength of shackle pins on behalf of the British Standards Institution, and in Specification No. 825 of 1939, has given formulæ and correction factors correlated with the bows of shackles. Whilst these results are satisfactory for the purpose, there is still a lack of information regarding the general case of a simply loaded short beam.

The only virtue of the existing beam formulæ for short beams is that a designer is certain of erring on the safe side. Difficulty arises, however, when an inspecting engineer is required to give a safe working load for a crane or other lifting machine. Calculation will oblige him to reduce the rated load of the appliance owing to the size of, perhaps, a pin, whilst he is well aware that in practice the part is amply strong enough for a higher load.

In attempting to obtain information on the subject, the writer has searched many text-books and approached several persons regularly engaged on the testing of materials, but so far without result.

p.p. Inspecting and Annealing Engineers, Ltd.
M. F. BARNES.
Director.

Birmingham, April 2nd.

* The application of the dynamo-electric machine as a dynamometer has been described by Professors Langer and Finzi in *Z.d.V.d.I.*, vol. 58 (1914), pages 41–46, and by Professor B. Haigh in *Engineering*, January 30th, 1931, pages 129–131.

Sixty Years Ago

THE CANAL BUILDERS

AT a meeting of the Institution of Civil Engineers on April 13th, 1880, a motion was introduced by the Council proposing that Monsieur de Lesseps should be elected an honorary member in recognition of his services to the science and practice of engineering by the conception and completion of the Suez Canal, "one of the grandest and most important public works of modern times." The proposal was received with acclamation. While the applause was at its height de Lesseps himself entered the room. Later in the evening he addressed the meeting in French. He said that soundings and levels for the Panama canal had been taken, and after spending sixty days in America he had come to the conclusion that the canal was a practicable undertaking. He was supported in that opinion, he remarked, by engineers of standing in all the principal cities of the United States and it was reasonable to suppose that in the interests of the community the construction of the canal would not be allowed to suffer from the promptings of the Monroe doctrine. In some respects, he asserted, the construction of the Panama Canal would be easier than that of the Suez canal. . . . In the same issue we reported that a preliminary concession had been granted to Herr Dahlstrom for the construction of a ship canal from the Baltic to the North Sea and that the plans for it had been prepared. The canal would run from the Bay of Kiel to Brunsbuttel in the estuary of the Elbe. It would have a depth throughout of 20ft. 9in., a width on the surface of 160ft., and a width at the bottom of 64ft. By the adoption of "a peculiar system of locks and reservoirs" provision would be made for increasing the depth of water to 25ft. or 26ft. whenever it might be desirable so to do. That depth would allow the passage through the canal of the heaviest German ironclad then afloat—the "König Wilhelm," a vessel of 9603 tons displacement and drawing 26ft. It was estimated that the canal could be completed in six years, and that it would cost £3¾ millions. In size the canal would be comparable with the Suez canal which had a surface width of 172½ft., a depth of about 26ft. 3in., and a bottom width of 70ft. . . . The Kiel and the Panama Canal are now in being. It is otherwise, however, with a third canal mentioned in the same issue, that between Bordeaux and Narbonne whereby ocean-going ships would be able to pass between the Atlantic and the Mediterranean. We reported that a circular supporting the construction of such a canal had been addressed to the members of the French Senate and Chamber of Deputies by Monsieur Duclerc, Vice-President of the Senate. Monsieur Duclerc described the project as a work of national preservation and urged that attention should be paid to its military, economic and commercial advantages. French engineers still continue to discuss this scheme at frequent intervals, but nothing so far has come of it.

THE WORLD'S STEEL OUTPUT.—It is estimated by the American Iron and Steel Institute that the total world production of steel last year was 149,330,000 net tons, of which about 35 per cent. was produced in the United States. It must be pointed out that the net tons referred to are of 2000 lb. and in the future all statistics of the Institute will be given in short tons and not in tons of 2240 lb.

Ventilation of Electrical Machinery at a Steel Rolling Mill

THE plant, illustrated herewith and on page 376, for the forced ventilation of the electrical machinery driving the new steel strip rolling mill recently erected for John Summers and Sons, Ltd., was provided by the Visco Engineering Company, Ltd., of Croydon. The equipment deals with the continuous hot strip mill, the cold rolling mill, and the slabbing mill, and comprises ventilating, air cooling, and air filtration plant.

The ventilation of the hot strip mill main motors and motor generators is carried out by means of four Howden "Silent Vane" fans. These fans draw the warm air from the motor room, force it through air coolers, and then deliver it through the motors and back into the motor room. The fans are of the double inlet, double width type, with curved back impellers having non-overloading characteristics. Each fan is driven by a 35 B.H.P. English Electric motor of the protected squirrel cage pattern, and is capable of handling 40,000 c.f. of air per minute. The fan outlets are fitted with volume control dampers. One of these fans with its driving motors is shown inside the filter chamber, in Fig. 1, page 376.

In order to remove the carbon dust given off by the motors, the air from one of the fans is passed through a "Visco" "C.E." dry cell filter, shown in Figs. 2 and 7. Approximately one-fourth of the air in circulation is, therefore, filtered before returning to the motor room. The filter consists of 180 sections, each comprising five removable V-shaped cells mounted on an iron frame. The filtering medium is composed of pads of special cellulose wadding which effectively extract the dust, while offering low resistance to the air flow, the filter being so constructed that there is no risk of air by-passing the filter element. The capacity is 35,000 to 40,000 c.f.m. A make-up fan with a similar filter is installed at one end of the building. This fan, which is shown in Fig. 3, forces 50,000 c.f.m. of filtered air into the basement, so that the whole building is under a slight plenum. This make-up air also allows for leakages through doors, crevices, &c. The fan is driven by a 40 B.H.P. English Electric motor.

The air is cooled by air coolers which are also situated in the basement. Each cooler has a capacity of 40,000 c.f.m. The coolers are of the gilled-fan tube type, and consist of three sections in series, and two in parallel. The air passes over the outside of the tubes, through which flows cold water from an adjoining well. Control valves are fitted on the water inlets and outlets, and each cooler is fitted with a thermometer. Fig. 8 shows one of these coolers taking air from the fans shown in Fig. 7. Two of the coolers are shown in Fig. 4. The wire grid between the two coolers is the delivery side of the 50,000 c.f.m. make-up fan shown in Fig. 3.

There are six further "Visco" coolers in this hot mill plant. Two of them are fitted in the foundation work of two 2500 H.P. synchronous English Electric motors which are provided with integrally built fans, the air passing from the motor outlets into the foundations, through the coolers and back to the motor inlet in a closed circuit. The other four coolers are fitted in a similar manner to two 7900 H.P. English Electric synchronous motors. The necessary ducts and closing plates on these motors were also provided by the Visco Engineering Company, Ltd.

The ventilation plant for the cold mill electrical machinery comprises three fans each of 40,000 c.f.m. capacity driven by 35 B.H.P. motors. These fans and motors are interchangeable with those used in the ventilation of the hot mill. The air passes through a filter, of the viscous type, into the fans whence it is discharged into the ducts and foundation work. The filter is of the "Visco" patented rotating self-cleaning pattern and has a capacity of 120,000 c.f.m. It consists of a number of metal baskets each containing sinuous filter plates which divide the air stream into thin layers. The filter plates are coated with a thin film of "Viscinol," a blend of light viscous mineral oils. The direction of the air flow through the filter is constantly changed by the sinuous plates, while the comparatively heavy particles continue in their original direction and are thrown against and retained by the "Viscinol" coated surfaces. The baskets are arranged one above the other with one spare basket, and, by an ingenious method of gearing the bottom basket can be lowered into a bath of "Viscinol" for cleaning and re-oiling, while the spare basket moves into position at the top of the column. The rotating mechanism is operated by a hand crank. The three fans are shown in Fig. 5, and the self-cleaning filter in Fig. 6.

In the slabbing mill the ventilation of the machinery is carried out by means of a 43,200 c.f.m. fan, driven by a 40 B.H.P. motor. The fan, motor, and starting equipment are interchangeable with the make-up fan on the hot mill machinery ventilating plant. The air is delivered to the basement which serves as a plenum chamber from which ducts lead to the various machines. This ventilating equipment is in close proximity to a coal tippler, and in view of the exceptionally dirty atmosphere, the air, before flowing through the concrete duct work into the foundations of the electrical plant, is passed through a "Visco" self-cleaning filter fitted with special oil spray cleaning. With this equipment, a rotary pump forces the oil at medium pressure through spray nozzles. Each filter basket is effectively dealt with, one each day, the oil being delivered with sufficient force to wash off all foreign matter. The oil pump and delivery pipe are visible in Fig. 9. The oil pump is provided with special control gear, so that it can be either hand operated, or controlled by a time switch. The filter itself is operated by hand, when the cells reach the cleaning switch, and automatically stopped after a predetermined and adjustable length of run by a time switch. A set of sheet steel fresh air intake louvres is fitted on the air intake side of the filter to give protection from the weather.

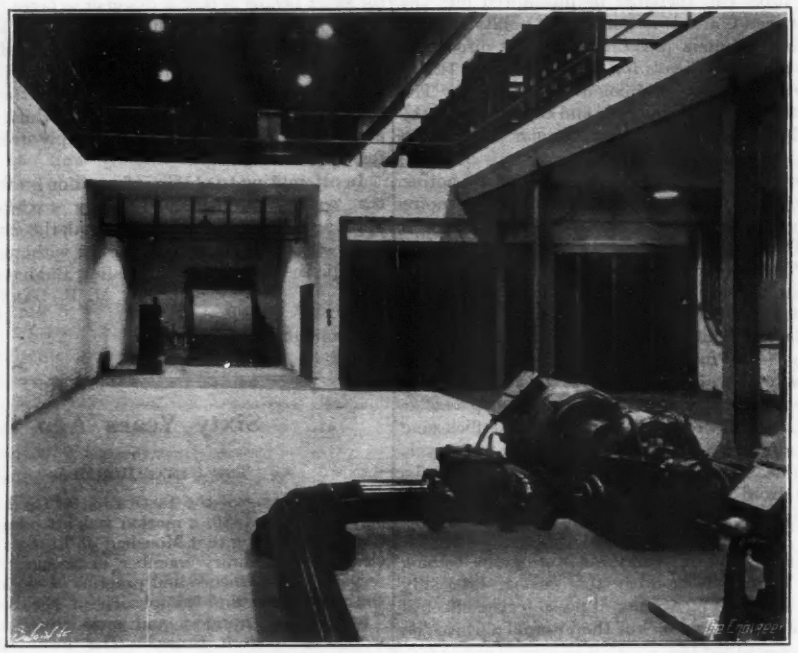


FIG. 7—FAN AND DRY CELL FILTERS FOR HOT MILL

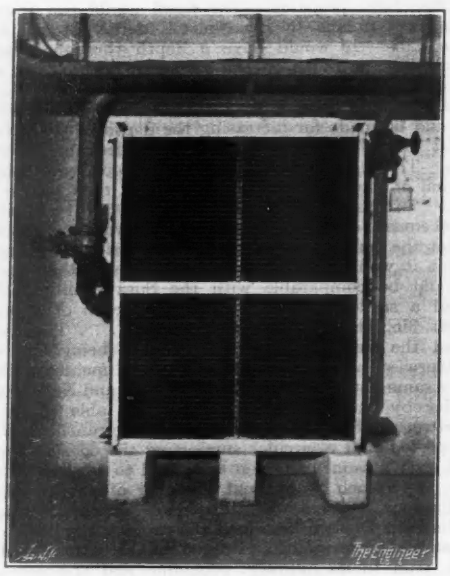


FIG. 8—AIR COOLER FOR HOT MILL

FIG. 9—FAN AND FILTER CHAMBER FOR SLABBING MILL

Pulverised Coal for Steel Furnaces

AT an American plant having seven basic-bottom open-hearth furnaces, pulverised coal was substituted for fuel oil owing to the wide fluctuations in cost of oil. A trial at one furnace showed that the siliceous ash in the coal would not seriously influence the basic slag, but that the coal must be thoroughly dried and pulverised to a much greater fineness for successful use. The pulverisation required is to put 90 to 95 per cent. through a screen of 240 mesh, the control of fineness being obtained through a vacuum separator. On test a 1 lb. lump of coal 3in. in diameter, having a total surface of about one-fourth of a square foot, gave a surface of particles exposed of about 3745 square feet. This finely divided coal is fed to the burner by a double-pitch screw conveyor, driven by a variable-speed motor, so that the operator has a very flexible control of his fuel supply. The coal falls into a 2in. horizontal pipe within a 5in. pipe, and at the back is a ¾in. pipe admitting air at 80 lb. pressure for atomising. Within a 5in. pipe a 16 ounce blast is maintained by a centrifugal blower, and this pipe tapers to a 3in. nozzle. The flame is short and a universal joint in the nozzle permits the melter to direct his flame. There is more slag than with oil, necessitating a removable slag pocket. As the very fine coal flows like water, all joints need to be tight, and the bins quite smooth so that coal will feed without hanging and then coming down suddenly. Nearly a million tons of steel have been melted, with 300,000 to 400,000 tons of pulverised coal. Melters must be trained, as they are likely to wish to soften the intensely hot short flame with the idea of saving the furnace roof. It is considered that with adequate engineering study to perfect the pulverising equipment and adapt furnace design to the most effective use of the coal, the present economies could be greatly increased, and the fuel used also for annealing and other furnaces. Some trials made several years ago were unsuccessful, probably because the equipment then used for cement kilns was not adaptable to open-hearth furnaces.

INDUSTRIAL HEALTH IN WAR.—The first emergency report of the Medical Research Council Industrial Health Research Board deals with industrial health in war, and consists of a summary of research findings capable of immediate application in furtherance of the national effort. It is claimed that by the adoption of the measures recommended in the report the efficiency, health, and comfort of workers in factories can be improved, production increased and discontent and fatigue avoided. It is based on the results of many years' research and the subjects dealt with include output and fatigue in relation to excessive hours with insufficient intervals for rest; effects of inadequate or unsatisfactory lighting, heating, and ventilation; causation and prevention of accidents; recording of sickness absence and accidents as a guide to loss of efficiency and well-being. The evidence and arguments are clearly and simply stated and the book will be of considerable interest to all engaged in wartime industry. It is issued by H.M. Stationery Office, price 6d. net.

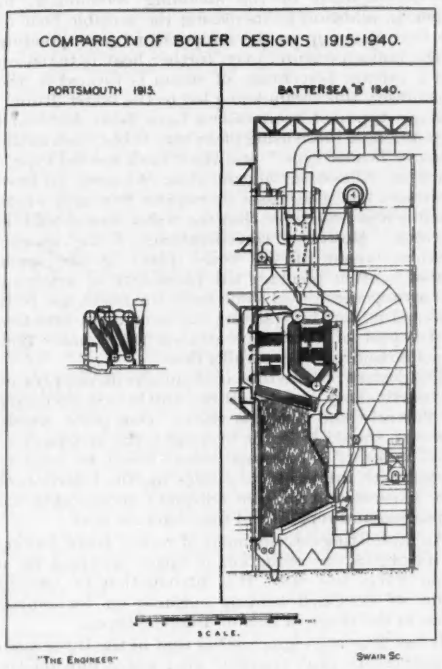
Development in Design of Boilers and Boiler House Auxiliaries*

By A. POLLITT, M.I. Mech. E.

Natural Circulation Boilers

Of all the vast changes which have taken place in the designs of boilers over the years, perhaps the most striking is the increase in size and output of single units.

As an example of this within the author's experience, Fig. 1 shows a comparison of the small 18,200 lb./hr. hand fired boilers with which the author was associated in the emergency generating



Output	18,200 lb./hr.	Output ...	550,000 lb./hr.
Pressure ...	200 lb./sq. in.	Pressure ...	1420 lb./sq. in.
Temperature...	578 deg. Fah.	Temperature	965 deg. Fah.
Feed temperature	100 deg. Fah.	Feed temperature	400 deg. Fah.

Heating Surfaces

	sq. ft.		sq. ft.
Boiler	4512	Boiler and walls ...	23,340
Superheater	470	Superheater	14,540
	——	Economiser	20,713
	4982	Air heater...	170,000
			228,593
Grate area	75	Grate area	918

Fig. 1—*Comparisons of Boiler Designs, 1915–1940*

station at Portsmouth dockyard in 1915, and the latest 550,000 lb./hr. retort stoker fired boilers being installed at present in the Battersea "B" station of the London Power Company. Both the illustrations are drawn to the same scale and the increase in size will be self-evident. The technical particulars of each of the boilers are added below the drawing.

The heating surface per unit of output of the boiler proper of a modern unit has been progressively decreased over the years due to the combination of many factors.

In the first case, the provision of extensive radiant water wall surface in the combustion chamber has reduced tremendously the amount of work to be done by the pure convective surface of the boiler. Also, the increase in feed water temperatures due to the adoption of bled steam feed water heating, coupled with the extensive use of economisers, has reduced the sensible heat to be added to the steam.

Again, as the operating steam pressure is increased the latent heat required to convert water at saturation temperature to steam is reduced very considerably, and as final steam temperatures are raised, the amount of work to be done in the superheater becomes a greater proportion of the whole heat to be added to every pound of steam raised.

In this connection the typical steam conditions given in Table I are of interest.

The decreasing percentage of the total work done in the boiler and water walls will be clear from this Table, and when this is coupled with the greatly increased heat transfer in the water walls the diminution of the remaining amount of work to be carried out in the boiler proper will be clear.

All the factors mentioned above, coupled with the great improvements which have been made in the technique of heat transfer from flue gases to water and steam contained within tubes, have reduced the amount of boiler surface required.

As to types of boilers, these are, of course, legion, but excluding special forced circulation boilers, to which reference will be made later, it is usual to classify natural circulation boilers under two main headings, namely, bent tube and header types.

There are strong adherents to both types, but taking an unbiased view, it appears that the general tendency of large power station boilers is towards the adoption of the bent tube type, a swing which can also be noticed in the present trends in the United States. It is probable that increase in operating steam pressures has played its part in this connection, since the bent tube boiler may be said to have the advantage that it eliminates the large number of joints required for hand-hole caps, &c., with the header type, thus reducing the possibility of leakage and the outage time required for annual overhaul.

Turning now to the general question of water walls, to which reference has been made, these are being used very extensively in all latest boiler designs, the two main features being, first that due to the high heat transfer rates obtained with these radiant walls the amount of pressure heating surface is very substantially reduced, and hence a greater evaporation can be obtained within a given space, and secondly that with their adoption the use of refractories in the combustion chamber is very much reduced, thus eliminating a source of potential outage.

In the earliest designs of water walls the tubes were embedded in the refractories themselves, as, for example, the well-known Luloff type of wall, but more recently the tendency has been towards the arrangement of the tubes themselves standing in front of and unprotected by refractories.

The further development has been the close pitching of these tubes so that they present an almost complete metal wall in the combustion chamber. This end has also been achieved in certain cases while still retaining wide pitched tubes, by bedding metal blocks on to the tubes, and well-known types of these are the Bailey, Taylor, and Foster Wheeler, which are illustrated in Fig. 2. In some cases radiant superheaters have been arranged in the water walls by interlacing superheater tubes between the water wall tubes.

Experience over the years has demonstrated the great importance of providing cold downcomers or feeders for the bottom headers of water walls and providing ample uprisers between the top headers of the walls and the steam drum. It is also necessary to take particular care to distribute these upriser pipes evenly across the boiler drum itself, in order to avoid creating too great a disturbance in the drum by the heavy localised discharge of steam and water mixtures.

TABLE I.—*Variation in Heat Absorbed in Different Portions of Boiler Plant with Variation in Steam Conditions*

Condition		1	2	3	4	5
Steam pressure	lb./sq. in. ga.	150	200	375	625	1420
Steam temperature	deg. Fah.	D.S.	650	800	875	965
Feed inlet temperature	deg. Fah.	100	180	250	340	400
Saturation temperature corresponding to pressure	deg. Fah.	366	387·9	442·2	493·3	590·3
Feed water outlet temperature from economiser...	deg. Fah.	—	260	340	430	500
Sensible heat taken up in economiser	B.Th.U./lb.	—	80·8	92·6	96·8	112·8
Heat taken up in boiler (and water walls)	B.Th.U./lb.	1128·0	971·8	894·4	795·5	684·7
Heat taken up in superheater	B.Th.U./lb.	—	146·1	210·9	244·3	297·3
Total heat added per lb. of steam raised	B.Th.U.'s	1128·8	1198·7	1197·9	1136·6	1094·8
Percentage of heat added in :—						
Economiser	per cent.	0·0	6·7	7·7	8·5	10·3
Boiler and water walls	per cent.	100·0	81·1	74·7	70·0	62·5
Superheater	per cent.	0·0	12·2	17·6	21·5	27·2
Total	per cent.	100·0	100·0	100·0	100·0	100·0

Forced Circulation Boilers

Forced circulation boilers have been developed principally on the Continent, although there are some notable examples in this country, such as the Loeffler boilers installed in the Brimsdown station of the North Metropolitan Electric Power Supply Company, the La Mont boiler at the Deptford West station of the London Power Company, and the Sulzer boilers in the Bargoed colliery of Messrs. Powell, Duffryn, Ltd.

As the author has been intimately connected with the La Mont boiler at Deptford West, it will be sufficient for him to limit his remarks to some particulars of this installation.

The boiler has a normal evaporation of 280,000 lb./hr., a maximum continuous rating of 350,000 lb./hr., and raises steam at 375 lb./square inch and 780 deg. Fah. from feed water at 250 deg. Fah. It is interesting to record that the unit has been arranged in the space and between the actual building columns provided some ten years or so ago to accommodate the natural circulation boilers having a normal economic rating of 75,000 lb./hr., and a maximum continuous rating of 95,000 lb./hr. Although a modern natural circulation boiler of somewhat greater output than the latter could probably be accommodated in the space available, it is doubtful whether such a high rating as 350,000 lb./hr. could be obtained. It is fired by a Taylor retort stoker and in addition to the very extensive water wall surface in the combustion chamber there are provided two evaporators, a superheater, and an integral double bank economiser. The tubes used throughout the unit are only 1½in. o.d., with thicknesses varying according to location.

One of the most important factors concerned in the design of forced circulation boilers of this type is that the resistances of the various water paths in parallel shall be similar, and this involves careful consideration and study in the case of water walls. A special arrangement of the tubes in the side walls is necessary, first, in order to give the required resistance as already mentioned, and secondly to ensure that each tube path is approximately equally heated. Attention is directed to the wall tubes adjacent to the stoker bed, these being furnished with abrasion strips.

The boiler is provided with three 100 per cent. capacity recirculating pumps, two of which are motor driven and one steam driven. Elaborate protective devices have been arranged on the boiler to ensure, if at all possible, that circulation should be maintained, and in the event of this not being possible from any cause the boiler is automatically shut down.

In normal practice one of the motor driven circulating pumps is in service and in the event of this failing, as indicated by a drop in differential pressure across the water circuit, the steam driven pump is automatically brought into service, whereby the differential pressure is restored. However, if for any other cause the circulation ceases, then the protective devices cause the fans to be shut down, cut off the fuel supply and cause the unit to cease giving any output. The provision of the three pumps and the elaborate protective devices is a precautionary measure, and it is anticipated that in future installations, after satisfactory operation of this type of boiler has been definitely established, less elaborate arrangements need be provided.

Superheaters

(*a*) *Designs of Superheaters.*—The gradual increase in steam temperatures over the years has naturally brought into great prominence the design of superheaters. This, coupled with the increase in feed water inlet temperature, the reduction in latent heat of steam due to rising steam pressures and the adoption of extensive water wall areas, which have already been mentioned, has had the effect of reducing very considerably the amount of boiler heating surface as such, and the replacement thereby of large superheater surfaces. Also, with increases in steam temperature, it has been necessary, in order to obtain the necessary temperature head, gradually to move forward the superheater towards the combustion chamber.

The necessity for more accurate steam temperature control, to which reference will be made a little later, has also brought about the two-stage superheater.

As the final steam temperatures have gradually increased to figures approaching that at which the physical properties of the metal deteriorate rapidly, it has been necessary to reduce the temperature difference between the metal of the tubes and the steam within the tubes, and in order to attain the necessary scrubbing action on the inside of the tubes to accomplish this, velocities and mass steam flows within the tubes have been increased.

Whereas with older designs using moderate steam temperatures, a pressure drop across the superheater of about 20 lb./square inch was usual, nowadays with high pressure and high temperature superheaters it is not unusual for this pressure drop to be increased to as much as 100 lb./square inch, consequent upon the adoption of higher steam flow rates.

Another interesting development in connection with superheater designs in recent years has been the combination of the radiant and convection type in a single unit. The convection type superheater has a steadily rising steam temperature characteristic with increase in load, whereas the characteristic of the radiant type is reversed. By suitably proportioning the relative amounts of radiant and convection surfaces and by passing the steam in series through the former and the latter, it is claimed that it is possible to attain a comparatively flat total steam temperature characteristic without the adoption of any special control devices.

(*b*) *Superheater Control.*—The gradual increase in superheat temperatures has continued to reduce the margin between the actual steam temperature and that temperature of the tube metal at which its physical properties fall off rapidly, in spite of the

* Abstracts from a paper to the Manchester Association of Engineers, February 23rd, 1940.

improvements in the latter resulting from the development of special alloys.

Those who have had experience with the operation of boiler plants will know only too well that the design figures for superheat temperatures from an ordinary uncontrolled superheater are subject to considerable variation under actual operating conditions, even at a constant load. Alterations to firing and combustion, changes of fuel and fouling of surfaces may effect changes of as much as 30 to 40 deg. Fah., even under seemingly similar conditions. If readings of steam temperature are taken over a considerable period on a given installation, during which the load is varied, in an attempt to establish a steam temperature-load characteristic, it will be found that the points, when plotted, do not lie on a smooth curve, but constitute a wide band of scattered points like the "Milky Way," through which only an approximate mean curve can be drawn.

Whereas the variation from the mean temperature did not involve any serious difficulties with more moderate steam temperatures, it may constitute a serious danger with higher steam temperatures in view of the possibility of temporarily overheating the metal. For this reason most modern plants with steam temperatures of 900 deg. Fah., or above, are provided with some form of thermostatically controlled devices which definitely limit the maximum steam temperatures.

The means provided to accomplish this control may be broadly divided into two classes :—

Gas By-pass Dampers. — Arranged in the flue gas path in way of the superheater, whereby some of the gas can be caused to by-pass the superheater surface.

Desuperheaters or Attemperators. — Arranged in the steam path through the superheater, whereby the steam is partially cooled by water.

Combinations of both these methods can be adopted in the same boiler unit and the actual method of application of either may and will vary considerably according to the particular design of the boiler.

In the space available in this section of the paper it is only possible to attempt to describe briefly a few of the applications, which, however, will, it is hoped, serve to illustrate the principle involved.

As an example of gas by-pass control, reference is made to the arrangements being provided on the 440/550,000 lb./hr. E.H.P. boiler for the Battersea "B" station, which are shown diagrammatically in Fig. 3.

It will be seen that the gases, after passing through the main section tubes of the boiler, rise vertically through the secondary and primary superheaters in series, and after turning through 180 deg. descend vertically through the bent tube section of the boiler. Between the latter and the superheaters is a gas passage running the full width of the boiler and in which are arranged twelve dampers in two groups of six, one group on the north side and one on the south.

These dampers are operated by rods carried out above the boiler casing to a cam shaft, on which the cams are set at various angles to cause the dampers to open in sequence. The setting is arranged so that the dampers do not open in strict numerical order, but in a manner which gives as even a gas flow across the boiler as possible.

The cam shafts are operated by small motors, the controllers for which are arranged on the boiler panel at firing floor level, these controllers being provided with indicators by which the operator can see at a glance how many dampers are lifted. As more dampers are opened less gas passes through the superheaters and hence the steam temperature is reduced. The dampers themselves are constructed in special heat-resisting alloys.

Actually, in this particular installation a combination of gas by-pass dampers and desuperheaters is provided to give a double security for control, in view of the very high steam temperature of 965 deg. Fah. The intention is to position the gas by-pass dampers by remote control for adjustment purposes required for general conditions of load, cleanliness, and firing conditions, &c., and to allow the desuperheaters to do the final regulation automatically.

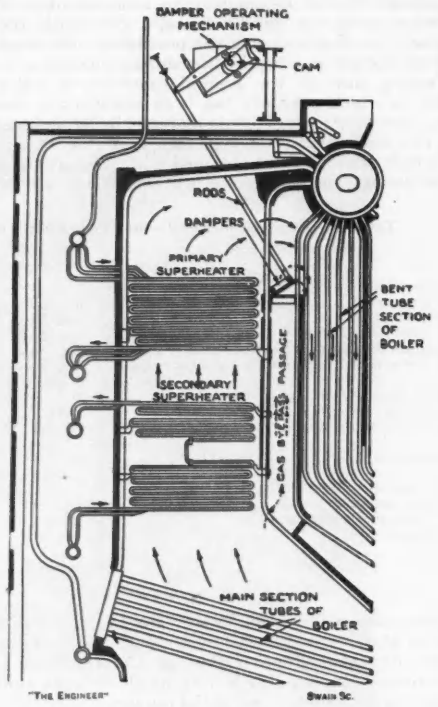


Fig. 3—*Superheat Control by Gas Bye-pass Dampers*

Desuperheaters can be arranged either on the outlet from the single superheater, or alternatively (and more usually) the superheater can be split into two sections with the desuperheater arranged in the pipe line between the two.

Economisers

The provision of economisers is such well established practice nowadays as to need little description. In their original form they comprised separate units built in the main gas outlet flues from batteries of boilers, the whole of the feed water for a group of boilers being passed through them to pick up a little heat before being delivered to the boilers themselves. They usually operated at low pressure and were of massive construction, with large bore tubes of cast iron, and little attention was paid to the attainment of high heat transfer rates.

With the passage of time this condition of affairs has altered and economisers have now become integral parts of boilers, a separate economiser being built into each separate boiler unit and arranged to deal only with the feed for that particular unit.

The rise in feed water inlet temperatures following upon the development of bled steam feed water heating in the turbine room has radically altered the operating conditions, and the result has been that for a given heat recovery the surfaces have had to be considerably increased due to the lower temperature heads available. This has led in some instances to the development of the steaming economiser, in which, in addition to increasing the sensible heat of the feed water up to the temperature corresponding to the boiler pressure, even further heat is taken up and a certain percentage of steam is formed in the economiser, this steam being led to the boiler drum.

Many types of economisers have been developed even amongst those using plain bare tubes, such as the "box or header type" and the "flash welded type." The most efficient arrangement is, of course, to have the water and gas passes in counter flow and where possible it is preferable that the water flow should be upwards. However, considerations of the general physical layout of the boiler plant in the space available often preclude the possibility of attaining this arrangement. In some cases the result has been obtained in part by splitting the economiser into two banks, part of which operates on the counter flow principle and part on parallel flow.

The designs of bare tube economisers do not present any particularly novel features, and it is unnecessary to illustrate and describe them. One point which, however, should be borne in mind is the avoidance of deep banks of tubes, and these should be built in groups with intermediate spaces for the insertion of soot blowers and to give adequate accessibility for inspection and repairs and maintenance work.

An interesting development of recent years, having as its object the reduction in space occupied for a given duty, has been the introduction of various forms of extended heating surfaces on economiser tubes in the shape of gills of different types.

It has long been appreciated that of the three main resistances to heat transfer, viz., water film on the inside of the tubes, metal of the tubes themselves and gas film on the outside, the last named was by far the greatest and was the real determining factor of the surface required for a given duty. It therefore appeared that if some means of increasing the area on the gas side relative to the area of tube wall and area on the water side could be developed, this would enable the general proportions of the economiser to be substantially reduced, and in particular would reduce the amount of pressure surface.

The method adopted in the case of medium and high pressure economisers was to shrink on to the outside of the bare steel economiser tubes, cast iron sleeves whose exterior was made in the form of gills, thus presenting to the gas side a vastly increased superficial area. In one of the earliest forms of this type the gill was made 4⅝in. external diameter and was pitched $\frac{11}{16}$in., being shrunk on to 2in. external diameter tubes. By this means an effective heating surface on the gas side of three square feet per foot

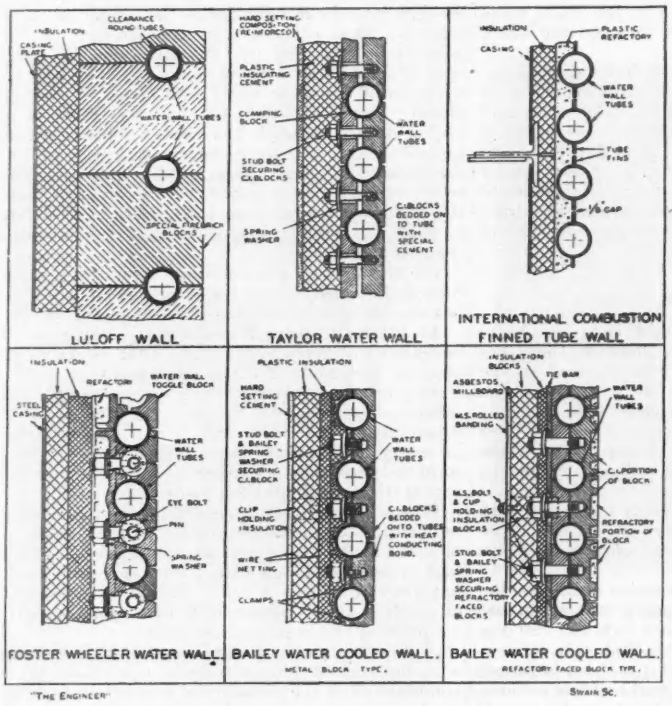


Fig. 2—*Typical Types of Furnace Walls*

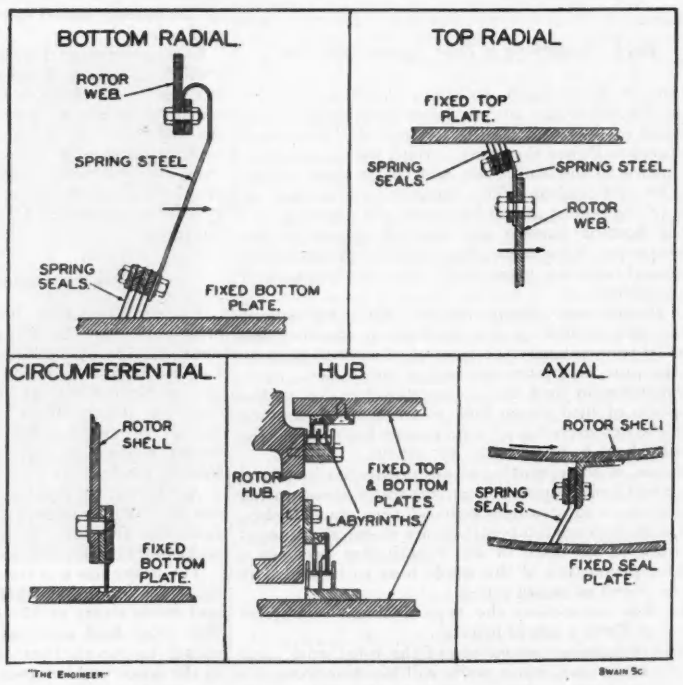


Fig. 4—*Seals for Regenerative Type Air Preheaters*

run was obtained. This represents an increase in superficial area of nearly 500 per cent. over that which would exist with a bare tube 2in. external diameter.

AIR HEATERS

The introduction of air preheating dates back some years now, but when first introduced it had as its object the improvement in boiler efficiency by usefully absorbing heat in the flue gases before being discharged to the chimney, and transferring this heat to the combustion air to the furnace. At the time that it was introduced this gain in efficiency could also have been partly achieved by installing larger economisers, since in those days feed water inlet temperatures were low, with the result that, first, the feed water had the capacity for absorbing this "back end" heat of the gases, and secondly the inlet temperature being low there was sufficient temperature head to transfer the heat to the tube surface.

The introduction later of bled steam feed water heating, however, altered these conditions, since unless steam economisers were installed, the possible temperature rise of the feed water between its inlet temperature and the saturation temperature corresponding to the pressure in the steam drum was reduced and, furthermore, irrespective of type of economiser, the gas outlet temperature was also necessarily increased, since this must always be greater than the feed inlet temperature in order to provide the necessary temperature head.

Air preheating therefore became the only means of achieving the low final gas temperatures requisite for the higher boiler efficiencies and the general heat balances of boilers had to be recast accordingly. Stokers and combustion equipment generally had to be designed to be suitable for higher combustion air temperatures. Whilst nowadays a limit of about 300 to 350 deg. Fah. applies to air temperatures for chain grate stokers, figures of from 450 to 500 deg. Fah. can be used on retort stokers, and even higher figures can be used for pulverised fuel firing if required. Modern designs of retort stokers are such that they impose no limitation on combustion air temperatures.

The amount of heating surface required for the transfer of a given quantity of heat per hour in an air heater is considerably more than in other convective parts of the boiler plant, due to the diminishing temperature heads available, as the final gas temperature is gradually reduced, but on the other hand, the heating surface, being of low pressure type, is relatively very cheap per unit of area. Air preheaters are therefore almost universally employed in all large modern boilers, and unless there is some characteristic of the fuel to be burnt, such as high sulphur content, &c., it is usual in the case of high efficiency base load boilers to design for a reduction in gas temperature to about 230 to 250 deg. Fah. and in moderate efficiency units for about 300 deg. Fah.

The types of air heaters in use to-day may be divided broadly into three main classes:—(1) Tubular; (2) plate; (3) regenerative.

The tubular type does not require any detailed description or illustration. The gases are usually arranged to flow through the tubes and the air outside, as by this means they can be easily cleaned. It is not possible to achieve very high heat transfer rates with this type of heater, with the result that a large heating surface is required and a considerable volume of space is required to accommodate a given heating surface. This is usually found to be greater with this type of air preheater than with either the plate or regenerative types, and it is therefore usually impossible to install tubular air heaters in locations where the space available is cramped.

For simplicity of construction it is usually endeavoured to arrange these heaters for single air and gas paths using long tubes, but this often involves difficulties in providing the necessary space for tube withdrawal. If, to obviate this, some form of multipass construction is attempted, it is usually found that the draft losses are too high and if the tube pitching is increased with a view to reducing this, the space occupied for the complete unit increases correspondingly.

The advantages of the tubular air heaters are that they are essentially simple in construction, can be rendered very tight so as practically to eliminate any leakage, and the tubes can easily be made of a sufficiently heavy gauge to reduce troubles due to corrosion.

With regard to plate type air heaters, there is a large number of different types on the market to-day, but in principle they consist of a number of sheet metal envelopes closely pitched, the air being caused to circulate through the envelopes and the gas through the interstices formed between the adjacent elements. The differences in design have reference to the means provided for improving the heat transfer coefficients, either by improving the air and gas flows, or by disposing the surfaces so as to give the increased turbulence and scrubbing action to both air and gas surfaces.

The comparatively narrow spaces formed between the leaves make this type of heater more liable to choking on the gas side. The possible building up of deposits as a result has had the effect, in cases where the heaters are working at low temperatures, of causing this moist deposit to become a seat for the concentration of corrosive acids, and considerable trouble has been experienced in recent years due to the eating away of the leaves of plate type air preheaters. Attempts have been made recently to minimise this feature by providing air and gas bypasses and air recirculation facilities.

Turning now to the regenerative type air preheater, there is really only one representative example of this type in this country, namely the Howden-Ljüngstrom preheater. In this design the heating surface is arranged in the form of a honeycombed drum, which is caused slowly to rotate in the air and gas passages. Whilst the heating element is in the gas side it picks up heat from the gases and as it slowly turns over into the air side, this heat is recuperated by the air.

The main advantage of this type of air preheater is that it occupies very considerably less space for a given duty than the tubular or plate types, but its disadvantage is that due to the moving parts there is an inevitable leakage. This leakage is associated with the designs of seals provided and is found to become more serious as the size of the preheater is increased.

The London Power Company has had occasion over a number of years to carry out considerable development work in connection with the designs of these seals, and as a result, CO_2 drops in large air preheaters have been reduced from figures of 2½ to 3½ per cent. to about 1 to 1½ per cent. In Fig. 4 are shown some typical designs of seals which have contributed to this result.

The underlying object of these various designs has been to produce a seal which is efficient and at the same time mechanically sound, without the elaboration of more theoretical types of hinged seals, which whilst quite satisfactory on an initial installation, have been found to deteriorate rapidly in service and so be rendered ineffective.

(To be continued)

Lorry-Mounted Air Compressor

LORRY-MOUNTED air compressor plants have many advantages as compared with the plant mounted on its own undercarriage and which has to be towed by, or loaded on to, a road vehicle when being transported from place to place. This is especially the case where comparatively small jobs have to be done in many places which may be at considerable distances apart, and such as occur in connection with large gas, water, and electricity supply undertakings servicing large areas, and in large urban and county areas where the authorities have considerable milages of road and auxiliary works to maintain. Many large public works contractors having, in some cases, scores of the ordinary type of portable air compressor plant, also find it advantageous to have one or two sets lorry-mounted for dealing quickly with small jobs, where the ordinary equipment is not immediately available.

For mounting on a standard commercial motor vehicle the compressor plant should be of compact overall dimensions. It is claimed that the sleeve valve air compressor, manufactured by Broom and Wade, Ltd., of High Wycombe, and illustrated herewith, as a result of the high speed for which it is designed and suitable, possesses advantages in this respect. Many compressor plants of this type have been built and mounted on standard commercial motor vehicles by this firm. The plant illustrated is one of two recently built to the order of H.M. Postmaster-General for the Post Office Engineering Department. It comprises a "Broomwade" standard SV2 portable petrol engine driven unit, embodying a twin-cylinder 5½in. bore by 4½in. stroke sleeve valve air compressor designed to deliver 110 cubic feet of free air per minute at 100 lb. per square inch pressure when running at 1200 r.p.m. It is directly driven by a four-cylinder petrol engine. The set is completely self-contained with radiator cooling and ample air receiver capacity. The plant in this instance is mounted on the customer's Morris 2-ton commercial chassis in the manner shown, and instead of the usual air delivery manifold adjacent to the air receiver, the delivered air is led from the aftercooler pipe between the air receiver and fuel tank, along the length of the chassis to air delivery cocks arranged tranversely at the rear of the vehicle.

Plants of this type can carry very complete tool equipment, and the plant described in this article is supplied with "Broomwade" pneumatic tools comprising two concrete breakers, two clay spades, two backfill rammers, and two rock drills, together with an assortment of steels, blades, &c., for each type, and four 50ft. lengths of pneumatic hose. The disposal of this tool equipment, together with blacksmith's tools for rock drill bits, plant tool kit, and instruction books, in such a manner that any single item is accessible for use without disturbing any other, and is also held securely whilst the vehicle is travelling has been effected very neatly.

Referring to the engraving, it will be seen that a large tool box is placed between the lorry cab and the compressor plant. It has a large hinged lid as well as large doors opening on both near and off sides. An upper compartment covered by the hinged lid carries steels, spade blades, &c., in racks, blacksmiths' tools, plant tool kit, and instruction books in special receptacles. In the lower compartment the side doors each give access to one concrete breaker and one clay spade, carried one above the other in special racks, to which they are secured by a strong strap. Additionally in this compartment, the coiled pneumatic hoses are also carried on racks. Supplementary tool boxes are fitted below the level of the foot board on each side of the compressor plant, one on the off-side for the rock drills, and the other on the near side, as shown in the engraving, for the back fill rammer. All tool boxes, a rack to accommodate three 2-gallon petrol cans and the steel canopy side sheets are provided with means for locking-up to secure the plant and tools against interference or pilfering when the vehicle is left unattended.

LORRY-MOUNTED AIR COMPRESSOR

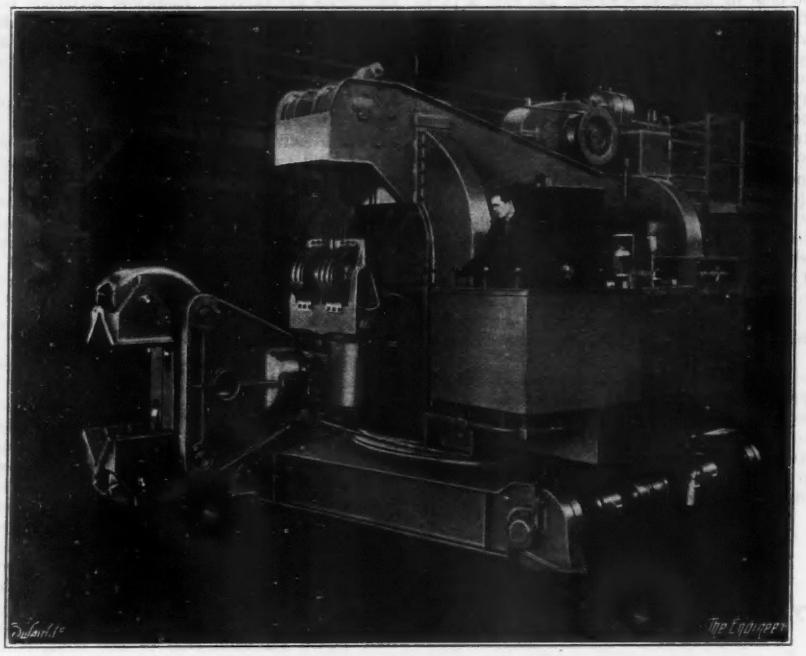
Forging Manipulator

THE accompanying engraving shows a typical forging manipulator as supplied by the Adamson Alliance Company, Ltd., of 175, Fenchurch Street, London, E.C.3. These machines, as their name implies, are intended for use with the forging press and manipulate the forging as it is worked by the press. The precise design of any machine depends to some extent on the arrangement of the forge shop. It may, or may not, be necessary, for instance, for the manipulator to be used for charging and drawing out of furnaces. In the simplest form the whole of the mechanism is mounted on a trolley which runs along straight rails laid in the floor and there is straight line and hoist travel only for the peel. But the machine becomes of much greater use if it is provided with a revolving motion and in certain instances bridge travel is also desirable.

On the constructional side it may be mentioned that

levelling of the peel in the horizontal direction is carried out by the use of motors and gearing.

Hydraulic operation is sometimes preferred for the hoist and the introduction of a shock valve in the system is claimed to eliminate shock in the vertical direction. A spring arrangement takes care of shock in the horizontal direction. Alternatively the hoist motion can be actuated by means of a hoist drum and ropes as illustrated in the accompanying engraving.



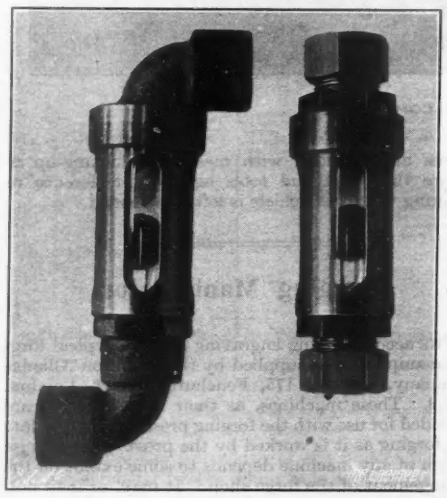
FORGING MANIPULATOR

In that case the drive is taken through totally enclosed gear-boxes. When dealing with round forgings the peel rotating motion is worked almost continuously and to prevent serious overloading of the drive when this motion is absolutely stopped by the press a planetary gear-box is used. The gear housing is mounted in bearings which permit it to rotate. Its outer surface is machined and polished and two adjustable brake shoes make contact with it and normally hold it stationary. When, however, the peel rotating motion is stopped by the press the whole gear housing slips and the gearing and driving motor are thus relieved of undue overloads.

In the more recent designs the tongs of these manipulators are operated by an oil-hydraulic system which is found to possess advantages not obtainable with mechanical operation or the use of compressed air.

Water Circulation Indicator

The indicator or tell-tale illustrated in the accompanying engraving has been designed by the Parsons Engineering Company, Ltd., of Southampton, to provide a visual means of verifying the water circu-



WATER CIRCULATION INDICATORS

lation in the cooling circuit of an internal combustion engine or for any similar purpose. It is known as the "Seeflo" circulation indicator.

The device consists of a gun-metal casing provided with openings through which there can be seen a large-diameter glass tube. The tube is fitted into and protected by the casing, and is held in position by water connections at each end. In the tube is placed a ball of special composition, having indentations so arranged that, whenever water passes through the indicator from bottom to top, the ball is lifted from its seat and suspended part of the way up the tube, according to the flow, and is continually rotated. This last-named action is valuable in that the glass is thereby automatically kept clean. In addition these indentations prevent the ball from sealing the inlet, and therefore the device cannot act as a non-return valve in the engine draining system.

It is claimed that the material of which the ball is made is not affected by hot salt or fresh water. Its specific gravity is such that it is nearly buoyant, and it is therefore lifted immediately by even a small stream of water. The material of the indicator is non-ferrous throughout.

Four sizes are in production, suitable for ½in. to 1¼in. bore piping. The larger sizes are provided with flanges at both ends for the attachment of the circulating pipe.

A New Gear Tooth Hardening Machine

A new "Shorter" type surface flame-hardening machine which embodies a number of improvements is now being made by the Shorter Process Company, Ltd., of Sheffield. This process, which is particularly intended for gear tooth hardening, is now quite well known and consists briefly of rapidly heating the surface to be treated by a moving high pressure flame which is followed immediately by jets of water that quickly quench the heated area. This gives a hardened surface layer which gradually merges into the softer metal of the core.

The machine head, shown in Fig. 1, is mounted on a fabricated steel carriage having four runner wheels and moves backwards and forwards along guide ways over the cross carriage which traverses the length of the tank. An electric motor on the machine head carriage is coupled to the carriage wheel spindles

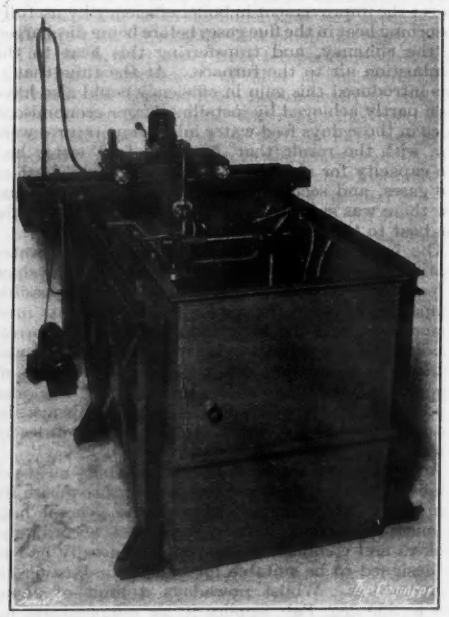


FIG. 2—GEAR TOOTH HARDENING MACHINE

through a spring loaded saw tooth clutch and the chain and sprocket wheel which may be clearly seen in Fig. 3. As the motor is not reversible the carriage is withdrawn at the end of the working movement by hand. The clutch is operated by a cam mechanism actuated by a small hand lever at the centre of the

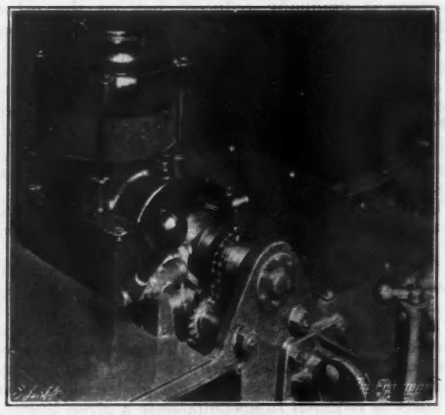


FIG. 3—CARRIAGE DRIVE

head and is designed to permit the instantaneous stopping of the feed. A substantial bracket projecting from the front of the head carries the blowpipe mounting unit which incorporates the various controls for setting the position of the flame in respect to the work. The front side plate of the machine

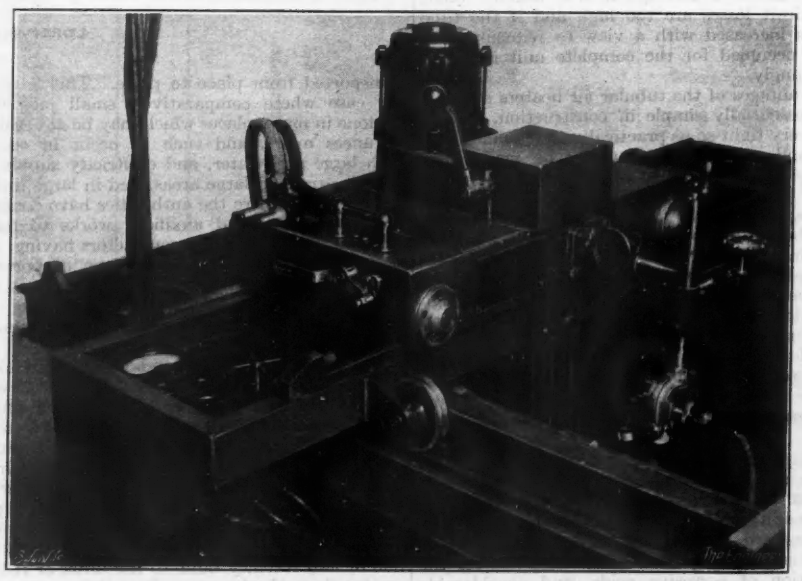


FIG. 1—MACHINE HEAD AND CARRIAGE

head is carried down in the form of a slotted apron. A rigid guide finger may be bolted to this plate and when in contact with a wheel to be treated, will, as it meshes with the helical or spiral tooth, revolve the wheel to bring the tooth progressively into proper relation with the burner. Thus the distance between burner and work is kept constant.

The motor on the machine head is worked in conjunction with a Ward Leonard set which consists of a main driving motor to suit current supply, directly coupled to a D.C. generator having an exciter end mounted thereon. This set is fixed on a welded steel bed, and may be set in any convenient position away from the machine. Fixed to the operating side of the carriage is a control panel. One control knob operates the shunt regulator in the generator field circuit and is so arranged that with an A.C. input to the set the first movement of the knob operates the contactor in the Ward Leonard set. Further movement increases the speed of the motor. A fine adjustment knob provided enables precise infinite gradation control. A final auxiliary switch allows the set to be stopped and restarted at any predetermined speed without alteration of the main control knob. The control panel is provided with a speedometer graduated in inches per minute to register from zero to 14in. The use of this set enables a stable final speed to be obtained within a variation of anything up to ten to one, a uniform torque being maintained throughout these limits, the speed being independent of the load.

The four wheels which support the fabricated steel cross carriage run upon rails formed along the side members of strong supporting frame around the tank rim. In the body of this carriage are the supply conduits for the coal gas, acetylene, oxygen, water, &c. The fuel valves are of the quick-acting, ebonite-seating type, actuated by a double camshaft and the acetylene or fuel gas cam has a lead over the oxygen cam to facilitate lighting up and to prevent oxygen impinging on the heated material when shutting off the gases. Regulators for oxygen and acetylene are included and there is also an electric regulator heater coil and lead to prevent freezing of the oxygen passages.

The tank is fabricated of ¼in. mild steel plate and incorporates the various waterways, sprays, water level control, &c., and the work holding pedestal is rotatably mounted on guides, fixed to the tank bottom. Work is mounted on this pedestal between cones or an arbor supported by vertically adjustable vee blocks. The burner has a travel length of 36in. and the machine can accommodate gears up to 6ft. in diameter.

Automatic Supervisory Control for a Pumping Scheme

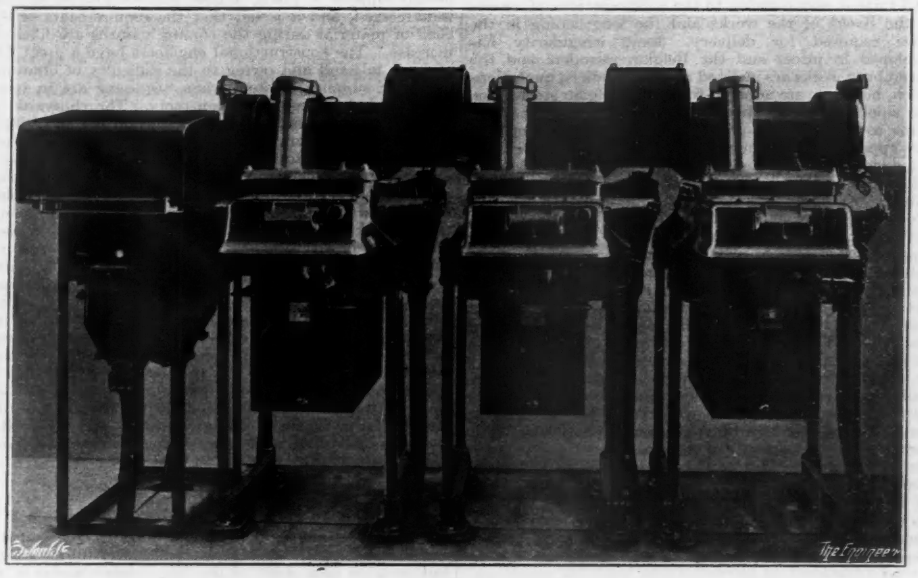
WHEN the water supply at the Shotton hot and cold strip mills of John Summers and Sons, Ltd., was found to be deficient in quality, it was decided to replace the source of supply by a series of deep well pumps at an average distance of four miles from the works, and 1½ miles from each other. The scheme, designed by the electrical engineer, Mr. A. G. Cutts, and carried out by Crompton Parkinson, Ltd., and the firm's associate, the British Electric Transformer Company, Ltd., with Brookhirst Switchgear and Evershed and Vignoles, Ltd., as sub-contractors, provides for power distribution to the load centre of the pumping stations by duplicate 11 kV cables. By means of supervisory control it is possible, through the master control indicating panel in the strip mill, to operate any or all of the pumping equipments either by hand control or automatically with the aid of automatic supervisory relays actuated by Midworth water lever recorders. The pump motors work at 400 volts.

Remote indication of the pumping load with the usual visual and aural alarm signals is provided for each station. The three-phase 50-cycle 11 kV power supply is taken to a standard ring main unit acting as H.T. isolating and two-way distribution unit. From this point the two 11 kV cables are taken to a central point in the pumping area, connected through another ring main unit and fed to the 11 kV bus-bars of a group of T.A.P. oil fuse Crompton Parkinson circuit breakers. Each circuit breaker controls the H.T. feed to a pumping site while direct connection is made to an 11,000/400 volt, 150 kVA B.E.T. transformer. The low tension supply to the 150 H.P. Crompton pumping motors is controlled by Brookhirst rotor starting panels with provision for isolating, manual, or automatic control. On automatic control, provision is made for two auto-restarts. The third trip locks out the starter, and at the same time gives visual and aural alarm via the pilots at the supervisory board. With a capacity of 65,000 gallons and a rise and fall of the water of 30ft., the reservoir is in the form of an inverted cone, supported at a suitable height on a steel structure.

Float-operated switchgear acts as a direct limit control and in the event of a safe high water level being exceeded disconnects the 440 volt supply. A second float operates a "Midworth" water level transmitter which transmits the level electrically to a recording dial and two relays on the main panel. The relays have dials marked in feet of water level, and a variable setting device, designed so that when any pre-determined low level is reached a signal can be transmitted over the pilots to start up the pump motors. One relay closes contacts on "automatic 1" position, the other, set at a different level, on "automatic 2" position. From the control board, the operator may select "manual," "auto 1," or "auto 2" position. Thus two stations may be on "auto 1," two on "auto 2", to come in at an appropriate level if the first two pumps are not providing sufficient water, and the remaining pump on "manual."

A fourteen-core pilot system using multi-core P.I.L.C. D.S.T.A. Crompton 0·003 cable has been installed. To six pilots of this system D.C. is supplied via a rectifier, one to each site with a common return. A D.C. high resistance pull-in coil on the motor starters closes contactor relays, but this D.C. actuating current is insufficient to energise fully the warning lamp and aural alarms in series with these pilot wires. After two trip outs, however, this coil is short circuited and sufficient current is allowed to flow to operate the alarms.

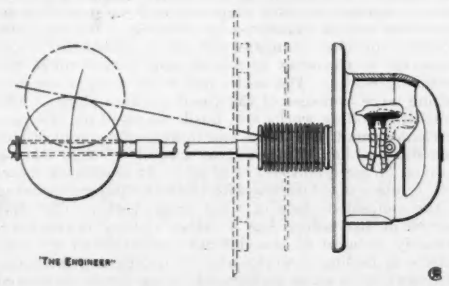
For telephones from the mill to the central H.T. switch control station, two pilot cores are utilised, while the remaining six cores transmit a current proportionate to that taken by each 150 kVA transformer primary. High tension current transformers are used and the secondary current is transmitted to Crompton ammeters, mounted on the central supervisory board.



E.H.T. SWITCHBOARD FOR AUTOMATIC PUMPING SCHEME

A Liquid Level Alarm

IN the accompanying engraving is shown the arrangement of a new liquid level alarm which is now being made by the Light Production Company, Ltd., of 60/66, Rochester Row, London, S.W.1. This unit has been particularly designed for use with tanks and other vessels in which the liquid level must be constantly controlled within close limits. It



LIQUID LEVEL ALARM

comprises a ball float, attached to a rigid arm, an extension of which is pivoted inside a metal bellows. This extension is free to move within a set arc according to the position of the float on the liquid in the tank. A mercury tube switch is fixed on the extension of the float arm so that as the level of the liquid alters the switch is rocked to close an electric circuit and operate the alarm. In order to overcome the surface tension of the mercury the trip mechanism is designed to provide a rapid and positive "make" or "break" when the float reaches a predetermined level. The spun metal bellows provides a liquid tight seal for the switch mechanism and at the same time does not restrict movement of the float throughout its working range. An inspection cover at the rear permits easy access to the switch mechanism from the outside and avoids the necessity of disturbing the whole unit when altering the switch setting. In the drawing is shown the position of the mechanism when the alarm is on and the dotted lines show the relative position when the alarm is off with the level of the liquid at a safe height.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

WARTIME STREET LIGHTING

(B.S./A.R.P. 37).—Although the installation of the new form of street lighting is in many parts of the country only just beginning, a revised edition of this specification has been issued. This revision, however, does not modify the provisions of the original edition (dated December, 1939), but extends them in a very useful direction. There are two main additions, these being :—(*a*) The inclusion of standard curves of light distribution for fittings intended for mounting heights between 9ft. and 14ft. (nominal mounting height, 10ft.) and for use where the spacing is less than 100ft. but is not less than 50ft. These fittings are designated "10ft. SS" to distinguish them from the 10ft. nominal mounting light fittings intended for spacings over 100ft. (*b*) An appendix has been added, giving notes on the design and testing of fittings purporting to comply with the specification. These notes are given primarily for the guidance of those concerned with the designing and production of fittings for which certification is desired, but they will doubtless prove of interest to a much wider circle of readers of the specification as the notes deal generally with photometric measurements at very low candle-powers. Copies of this revised specification may be had from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 6d. (8d. post free).

INCOMBUSTIBLE MATERIAL RESISTANT TO INCENDIARY BOMBS

(B.S./A.R.P. 27).—With a view to minimising the dangers resulting from possible incendiary bomb attacks of the enemy, active consideration has been given by the A.R.P. Department of the Ministry of Home Security to the development of materials which could be used in the attics and roof spaces of buildings so as to confine and afford protection against the incendiary effect of the bomb. In order to assist in the development of such materials a test has been devised by means of which the performance of materials under incendiary bomb effect may be ascertained. This method of test, together with the results which should be expected from a suitable material, has been made the subject of this standard. It is stated in a note to the standard that the method of test is one which has been in use for some time at the testing station of the Fire Officers' Committee, and it is indicated that the tests on materials will be made at the Elstree Testing Station on behalf of manufacturers who would like to have their materials examined. Copies of the above B.S./A.R.P. Standard may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1 (price 3d. post free).

ARCING IN MERCURY SWITCHES.—A report by Dr. C. G. Suits of the Research Laboratory of the American General Electric Company on arcing phenomena in mercury switches is reprinted in the March issue of the company's journal. Among the results of the investigations it was found that the arc duration for both the make and the break positions of the mercury switch is very sensitive to the kind of gas with which the switch is filled and, to a lesser extent, to the pressure of the gas. The best gas for short arc duration and maximum interrupting ability is hydrogen at the highest possible pressure.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

The Continental Steel Market

The position in the Continental steel market appears to have improved within the past week or two. The market is restricted owing to the war to the activities of the Belgian and Luxemburg works. German imports, of course, are blockaded, whilst the British and French steel industries are unable to take full advantage of their export opportunities owing to the tremendous pressure of the home demand for war purposes. The Belgian works are reported to be in a fairly satisfactory position although their outputs are restricted by difficulties regarding supplies of raw material and labour, the latter as a result of so many of the men serving in the army. Orders from overseas consumers have been on a moderately good scale of late, particularly from neighbouring countries including Holland. Recently Cosibel, the central export selling organisation of the Belgian works, after investigating the situation, announced that no further tonnages of finished steel would be at the disposal of the selling organisations until further notice owing to the accumulations of orders on the books of the works and the lengthening in the times required for delivery. Some irregularity has developed in prices and the Belgian re-rollers and the Luxemburg works are inclined to cut the official quotations which, however, are adhered to by the Belgian steelworks. The chief concern of the Belgian and Luxemburg works seems to be the development of American competition. This appears in most unexpected quarters and is regarded as a serious factor in the situation. In bars, for instance, Belgian and Luxemburg makers quote Frs.1700 to Frs. 1750 f.o.b., whilst the Americans are reported to have sold in Holland at the equivalent of Frs.1500 f.o.b. Antwerp. Joists have become rather scarce on the export market largely owing to the requirements of the Belgian home Government and the purchases by Great Britain and France. Luxemburg has been offering N.P. sections but the export demand seems rather quiet. The French steelworks are operating at capacity and their production, like that of the British, is largely for war purposes. In these circumstances little can be allocated for export, but at the same time an attempt has been made to retain a footing in those markets which normally may be regarded as French preserves. The latter, also, are somewhat troubled by American competition, but in their view it is the result of war conditions, and it is felt that the Americans are not likely to hold this advantage when peace-time trading is resumed. The platemakers on the Continent appear to be busily employed, largely upon orders from shipbuilders in Holland and Scandinavia. The price of Frs.2100 is fairly well held. Slight concessions are reported to have been made of late on attractive orders.

The Pig Iron Market

THE situation in the pig iron market has not changed over the past week or two excepting that the demand has increased in volume. The producers are doing their best to keep all consumers adequately supplied, and in this they are aided by the skilful distribution arranged by the Control. On the whole consumers are satisfied, and no reports have been received of any having to go short of the pig iron they require, although there is no doubt that some have to use iron of an analysis with which they are not familiar. This, however, is one of the inconveniences of the war, and was experienced to an even greater degree in 1914–18. There has been a distinct strengthening in the request for foundry iron of all descriptions, and it would seem that more of the light castings foundries have been put on to war work. Certainly the demand for high phosphoric foundry iron is greater and more widely distributed than at any time since the beginning of the war. The possibility of a relaxation in the restriction upon building activities under the new scheme of distribution has caused some hope of a revival in the demand for light castings. Low phosphoric pig iron is being sought after by users and the producers are experiencing strong pressure for deliveries. The output of this description has been increased somewhat, but it would seem that the demand is if anything rather in excess of production and consumers are becoming somewhat anxious. Low phosphoric iron is used in large quantities by the heavy engineering, motor, and machine tool foundries, almost all of whom are employed upon war work. In the Midlands, the light castings industry seems to be moderately well employed, although there is a considerable amount of idle plant. In this district, however, the quantity of high phosphoric pig iron taken up reaches a respectable tonnage and appears to be on the increase. The stocks of low phosphoric iron in the hands of the producers have been depleted, and it is not easy to see in what way output can be expanded. Consumers, therefore, are carefully conserving their supplies and in some cases supplementing them by purchases of hematite. The pig iron trade in Scotland has been quieter of late largely because of the dull conditions at the light castings foundries. Other descriptions of pig iron, however, are quickly taken up by the steelworks. Indeed, the demand in all districts for basic iron has reached large proportions, and is not easily satisfied even with the assistance of imports. The position in the hematite section is that most of the stocks held by the furnaces in the earlier part of the year have been used, and production although pressed to the utmost, is only barely holding its own against the insatiable demand.

The North-East Coast and Yorkshire

Although it is too soon yet to see how effective the new steel distribution scheme will be in view of the rather confused conditions which had developed at the works under the old licensing method, there are hopes that it will result in a system of orderly deliveries. Consumers have had to work under difficult conditions, since they had no guarantee when they would receive material ordered or what proportion of their order would be supplied. Under the new scheme users should know exactly when they will get delivery and the tonnage which will reach them. The change over to the new regime cannot, of course, be fully operative for some months, and for the time being the situation at the mills does not show much improvement. It is obvious, of course, that in wartime conditions there can be no slackening in work, nor at the moment can consumers' requirements be entirely met. In fact the works have to turn away a considerable amount of the business offering simply because they cannot promise any definite delivery. The position, however, has been further improved by the receipt of large tonnages of imported semis which has enabled the re-rolling industry to operate full time in an effort to reduce the orders which had accumulated on their books during the time semis were scarce. The big steelworks continue to turn out a huge tonnage of material which, great as it is, is not sufficient to meet fully the demand. The pressure to obtain supplies of joists, angles, and sections of all sizes is unrelaxed, and it is felt that the requirements of this class of material during the coming months are likely to increase. The constructional engineers have a great deal of work in hand and owing to the difficulty of obtaining adequate supplies of steel when necessary are in many cases behind against their contracts. The shipyards on the North-East Coast also are taking large quantities of shipbuilding steel and it is unlikely that there will be any falling off in this direction. The demand for plates is in excess of the capacity of the works to supply although production is being pressed to the utmost. The Yorkshire steel industry is struggling to meet the demands upon it and is looking forward to some relief from the present situation when the new distribution scheme comes into full operation. In the meantime the steelworks, particularly those in Sheffield, are working at a high rate and there is an exceptionally large production of billets. Consumers, however, complain of the difficulty of getting the material they require by the dates needed, although in view of the excessive demand this is not surprising. Apart from the general run of structural steel, such as plates and sections and the descriptions in more common request, there is a growing demand for special and alloy steels. Large tonnages of bright steel bars are being taken so soon as produced, whilst the call for stainless steel is on a heavy scale.

Scotland and the North

In all departments of the Scottish iron and steel trade production is being pressed to the fullest extent, but even so falls short of the large requirements of the consuming industries. The shipyards are insistent in their demands for material, since all the yards are fully occupied; and as the Admiralty has in hand a big programme of naval and merchant ship construction it seems unlikely that any relief will be experienced for several months, if indeed for the duration of the war. The heavy steelworks have been operating at capacity since the outbreak of hostilities and the manner in which they have been able to maintain their outputs has been one of the surprising features of the situation. Difficulty is being experienced by all classes of consumers in placing orders for plates and structural material. The former description of manufactured steel particularly is in heavy request, and the orders on the manufacturers' books cannot be completed for some time. Anticipations are prevalent, however, that the new scheme for steel distribution will ease the situation later in the year. It yet remains to be seen, however, to what extent the position will be affected by fresh steel requirements as a result of the naval and military activities of the past week. All the Scottish constructional engineering firms have as much work in hand as they can deal with and their requirements show no signs of diminishing. In fact, owing to the difficulties of placing fresh orders there is probably a considerable tonnage of work accumulating to be placed when this becomes practicable. The general as well as the marine and locomotive engineers are fully employed and are providing an outlet for record quantities of material. In fact, the provision of the quantities of steel needed by these industries is throwing a considerable strain upon the producing works. The boiler and tank makers are also seeking large tonnages of thick and medium plates. The Scottish re-rolling works are busily engaged on the production of small bars, strip, and light sections, and of late their outputs have improved as a result of their having received larger quantities of billets. It is difficult, however, to place new business with the re-rolling works owing to the congested state of their order books. The steel market in Lancashire has a rather quieter appearance, probably because of the difficulty experienced by consumers in finding a works able to accept new business. Engineering concerns in Lancashire are busily employed upon work of national importance and their requirements are heavy. Large supplies of bars and structural steel are being absorbed and there is an insistent demand for plates of all thicknesses by the tank and boiler makers. The Lancashire wire drawing works are operating at capacity and are finding it difficult to meet the demand. Pressure to secure supplies of alloy steels is increasing. High speed steel is in strong demand and the producers are hard pressed to meet consumers' requirements.

Copper and Tin

The firmer tone noticeable in the copper market last week received an accession of strength from the news of the German invasion of Denmark and Norway. Whilst there are no reports of further purchases of copper by the Scandinavian countries, possibly because of the uncertainty of obtaining delivery, Holland is understood to have inquired for a considerable tonnage. It is reported that early last week 4000 tons of copper were sold. On the news of this buying prices in the American domestic market also showed greater strength, the cheap offers from the customs smelters which had been circulating were withdrawn and the price was established at 11·50c., which is the quotation which the big producers have observed for the past week or two. The export price advanced successively from 11·05c. to 11·20c. and from 11·20c. to 11·50c. Much, of course, depends, however, upon whether American buyers will continue to take up copper, as it was thought that they had covered their requirements until the middle of May. In addition to Holland, which is presumed to have bought copper for armament purposes, Italy and Russia have been in the market, but the producers have shown little inclination to sell to the Soviet. It is understood that the Italians are anxious to buy unrefined copper for sulphate making; but there is some stringency in the supplies of this description and the refining works in Europe are understood to be experiencing a shortage. This was a feature of the copper position during the last war and may be expected to continue. Lately there has been a brisk demand from India and South America for copper, which has been easily met. In this country the latest development of the war may be expected to lead to an acceleration in the output of munitions, and it is probable that large quantities of copper will be required. There is no doubt, however, that the Control has the situation well in hand and that if greater tonnages are needed they will be forthcoming. . . . Firm and rather steady conditions have ruled in the tin market. Recent war developments have led to somewhat freer buying, which may be regarded possibly as a precautionary measure, since it is generally believed that consumers both in America and in this country are fairly well provided with tin. The backwardation, which shrank at the beginning of last week on some active selling of cash metal, widened again later. Although there has been no jump in prices the belief still persists that values are likely to appreciate when the effects of the last cut by the International Tin Committee become apparent in a lessening in supplies. There is no shortage of the metal in this country but it is thought that the stocks are if anything diminishing. American buying has been rather more active of late, but it is considered that consumers in that country are well covered. The American Bureau of Metal Statistics states that the consumption of tin in the United States in January was 6380 tons, which was the lowest monthly figure since August, 1939.

Lead and Spelter

The latest developments of the war in Scandinavia may result in an acceleration in the munitions programme and an increased demand for lead. So far, however, there has been no indication that larger quantities are passing into consumption. In fact, the situation in this market presents little change over the week. The Control seems to have efficiently regulated supplies to consumers, most of whom are already engaged upon war work, and no complaints are heard of work having to go short of raw material. The situation in overseas countries is not very clear, and seems somewhat irregular. In the United States values have declined, and the quotation now stands at 5c., in spite of the fact that consumers in America are reported to have been buying on a more active scale. American producers are said to be well sold and for this reason some surprise is expressed at the reduction in the price. Most of the Mexican lead appears to be going to France and Italy, and until recently some was exported to Scandinavia. The extension of the war to Denmark and Norway, however, is likely to check this business. Some interest is being taken in the position of Germany so far as supplies of lead are concerned, and the general view is that her situation is somewhat precarious and that the amount of metal reaching that country is small. Probably most of it is coming from Russia. British makers of manufactured lead products are understood to have been inquiring as to the possibility of joining the export drive; but so far little progress appears to have been made, and it is likely that the Control would carefully scrutinise any proposal to use lead for this purpose in view of the heavy call for the metal for munitions. . . . The situation in the spelter market in Great Britain is satisfactory and there has been no relaxation in the demand from either the galvanising or the brassmaking industries. Efforts are being made to provide spelter for those trades making exportable products, but after the munitions requirements are met there does not seem to be much surplus available, although as we have stated on other occasions there will be little difficulty in obtaining fresh supplies from Belgium if these were required. In all probability, however, Empire sources of supply will be found quite sufficient. Norway produces about 45,000 tons of spelter per annum, largely of electrolytic quality, and to a great extent relies upon imported ores. The recent war developments in that country are almost certain to check imports for a time, and as the works are situated in the Bergen district they are in the hands of the Germans. In the United States the demand, which had fallen off in recent weeks, developed a certain amount of strength on the news of the extension of the war. The price, however, remained unchanged at 5·75c. East St. Louis.

ACCIDENTS ON AMERICAN RAILWAYS.—According to Mr. J. J. Pelley, the President of the Association of American Railroads, in 1939 the railways of the United States had the best general safety record in their history. Thirteen persons lost their lives in train accidents, and of these fatalities nine occurred in one accident which, according to an investigation by the Interstate Commerce Commission, was caused by sabotage. Fourteen passengers were fatally injured in train service accidents in 1939. Train service accidents to passengers consist, for the most part, of accidents in getting on or off moving trains.

French Engineering Notes

(From our own Correspondent in Paris)

Women Workers

THE compulsory employment of women for work on national defence is organised on a larger scale, and with more careful preparation, than was the case in 1916. So far there is no compulsion on women, who apply to labour exchanges in sufficient numbers to justify the belief that as many as may be required will be forthcoming. In all works engaged on war production a percentage of women must be employed. The percentage is a minimum of 50, and varies with the character of the specialised occupations in which the degree of skill or physical effort may entail a more or less strict and limited selection of women workers. In some occupations the percentage is 90, so that an average of 70 per cent. is fairly near the mark. All private and official labour exchanges are under control of the Minister of Labour, and it is only through these exchanges that employers can obtain women workers, with some exceptions, and as works and factories are under the direct supervision of labour inspectors, employers cannot escape obligations imposed upon them by the decree. If they are not giving work to the required number of women, employers may be deprived of men workers who are only supplied through the Ministry of Labour. Before women are put on any work they are examined for physical fitness, and then pass into "orientation" classes with a view to seeing the specialised occupations for which they are fitted. In other words, a preparatory selection is made by experienced "monitors," similar to the method adopted by the railways. Employers are responsible for the preliminary training which must be done outside the shops, in which case employers are indemnified for the cost by tax remission, or they may send the women for training to schools specially created for the purpose. The periods of practical instruction vary from one week to four weeks for work on drilling machines, and from one month to six months for automatic and semi-automatic lathes. At the same time men doing the same specialised work are able to take advantage of the system of promotion recently introduced, whereby anyone showing natural ability and a desire to get on may be raised to a more skilled occupation, and while the skilled ranks are increased more men will be able to return to their military duties, and more women will fill vacancies for specialised work. This training of women and promotion of male workers has a bearing upon the obligation of employers to train a number of apprentices representing a minimum of 9 per cent. of the total number of men and employees in any one works. A beginning is made this year with 3 per cent. In November last a decree provided that the number of apprentices could be reduced in relation to the number of "promoted" workers and specialised women trained by an employer. It has now been decided that when an employer trains 18 specialised women workers or 12 adult promoted workers, he is entitled in each case to a reduction of one apprentice. Before that concession is allowed the trained women and adult workers are examined by the departmental committee of technical instruction.

Public Works

The credits amounting to 1800 million francs that were voted for public works during 1940 have been reduced by 835 millions, and no more undertakings will be put in hand unless they are absolutely necessary. Before the outbreak of war programmes of works for unemployment relief had been carried through for several years, but they were mainly national necessities, such as the reconstruction and widening of roads and bridges for motor traffic, and no unproductive work was put in hand for the mere purpose of providing employment. Money now authorised to be spent is for the completion of works. At no time has the unemployment figure reached half a million, including a large proportion of men too old or otherwise unable to work, and since general mobilisation and State control of labour, there are practically no unemployed. The Minister of Labour offers work to everyone, and men who refuse jobs lose their relief pay. There is no need to put in hand public undertakings when it is not easy to find sufficient labour for the vast amount of building and other work necessary for national defence, particularly the erection of factories. At least one aircraft factory has been extended underground for safety.

Naval Construction

After recently making a statement of accelerated progress in the construction of all types of naval vessels, including the four 35,000 ton battleships, most of which are now nearing completion or being fitted out, and all of which are expected to be in service by 1942, the Minister of Marine, Monsieur Campinchi, announced that another instalment of the naval shipbuilding programme will be put in hand immediately. Its tonnage will be close upon 200,000. While nothing of the constitution of this new building instalment has been revealed, the statements made by the Minister to the Marine Commission of the Chamber of Deputies leave no doubt that an adequate number of convoy ships will be laid down. He said that this instalment of the building programme was based upon experience of the past seven months, and that nothing could be neglected for the protection of merchant shipping. The principles guiding French naval construction are the same as those of the British. A noteworthy feature is the rapidity with which work is done in French shipyards. There have always been criticisms of dilatoriness in naval shipbuilding, but there is nothing now to criticise. New methods of work have been introduced to ensure the greatest possible economy of time, and with a longer working day the shipyards are doing far more than could formerly have been expected of them. The expenditure also provides for improvements to naval ports. For many years work has continued on the creation of the naval base at Mers-el-Kebir, near Oran, and since the outbreak of war it is being considerably accelerated. Mers-el-Kebir is already the strongest naval base on the North African coast. The strategical importance of the triangle formed by Toulon, Mers-el-Kebir, and Gibraltar is obvious.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TRANSFORMERS AND CONVERTERS

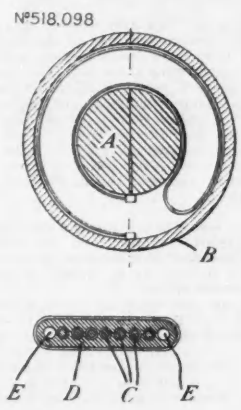
518,064. March 16th, 1938.—IMPROVEMENTS RELATING TO ELECTRIC ARC CONVERTERS, Allgemeine Elektricitäts-Gesellschaft, 2/4, Friedrich Karl-Ufer, Berlin, N.W.40, Germany.

In converters of the Marx type, large oscillations occur upon ignition and extinction of the arc, particularly where the voltage and output are high, and these oscillations result in radio interference and may also lead to back ignition in the converter. According to the invention, the oscillations are damped by providing choke-coils connected in series with the transformer windings and shunted by ohmic resistance; the leakage inductance and stray capacity of the transformer are made smaller than is usual, and the inductance of the commutating circuit is increased to the normal value by the inductance of the choke. The shunting resistance must be such that it does not unduly affect the action of the choke-coil in limiting the short-circuit current and yet, at the same time, it absorbs as much oscillation energy as possible. It follows from these two requirements that there is an optimum value for the ohmic resistance which can be found by experiment or by calculation for any particular installation.—*February 16th*, 1940.

TRANSMISSION OF POWER

518,098. August 15th, 1938.—MULTI-CORE FLEXIBLE ELECTRIC CABLE CONNECTIONS FOR ROTARY MECHANICAL PARTS, François Blanche, 17, Avenue Guitton, La Rochelle (Charente-Inférieure), France (assignee of Société D'Electricité Industrielle, a French company, of 12 Bis, Rue Réaumur, La Rochelle (Charente-Inférieure), France).

The connecting cable is arranged in an annular space rectangular in cross-section formed between the rotary part A and the fixed part B. The points at which the cable is connected to the fixed and rotary parts respectively are constituted by junction boxes furnished with connecting terminals. Thus, though the connection is of a simple nature, rotary movement can be effected in either sense through an angle of as much as 320 deg. In order that the conductors may be sufficiently flexible to avoid all fatigue, and the cable be sufficiently resilient to

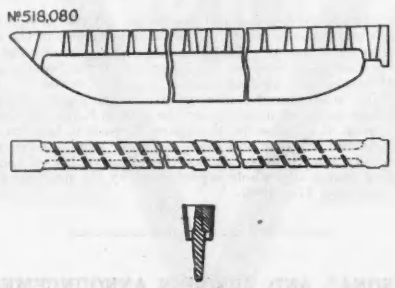


conform to the circular contours of the rotary and fixed parts, the multi-core cable may be constituted as shown. The flexible stranded conductors C are arranged side by side and embedded in an insulating sheath D so as to form a flat unit. Similarly embedded in the insulating sheath are two steel cords E, E, which ensure the springiness of the whole cable. When the cable has been placed in the annular space and connected to the two rotatable parts all the cores will be similarly flexed when the part A is turned. The cable is deformed in so far as it is bent, but, by reason of its springy nature, it will firmly bear against and conform exactly to the contour of the circular faces of the fixed and movable parts. The only stress liable to cause fatigue of the cores results from their flexure on a radius equal to half the width of the annular space housing the cable.—*February 16th*, 1940.

FURNACES

518,080. August 13th, 1938.—FIREBARS, Harold Alfred Halcrow Fruin, and Leslie Gilbert Holland, both of Bennett Chambers, 113, Hoe Street, London, E.17.

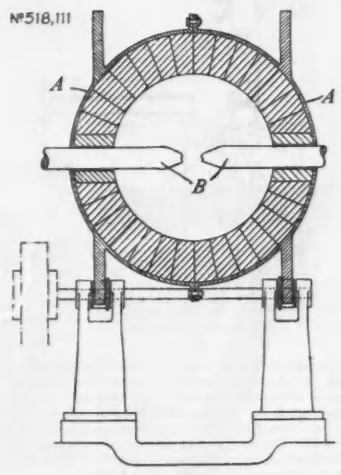
The design of the firebars is clearly shown in the accompanying drawings. The web of the firebar has at its upper end a bilaterally extending upper flange provided at its opposite sides



with a number of suitably spaced notches arranged in coaxial pairs, the axes of each pair of notches being inclined at an angle of approximately 60 deg. to the longitudinal axis of the flange. The notches are wedge-shaped in vertical longitudinal section and the transverse width of the central longitudinal zone of the flange between the notches is less at the upper surface of the flange than at its lower surface so that the notches are also wedge-shaped in transverse vertical section. The web member is substantially wedge-shaped in transverse vertical section. At the ends and at one or more intermediate points in the length of the firebar the sides of the upper flange or member are provided with projections so that when a number of the bars are assembled together side by side to form a furnace grate in the usual manner, narrow longitudinal spaces are formed between the sides of the flanges of adjacent bars. The upper surface of the grate thus comprises a number of longitudinal spaces between adjacent bars intersected by inclined spaces formed by the notches. This construction and arrangement is found to provide a highly satisfactory supply of air to all portions of the fuel bed, the firebars remaining comparatively cool in operation so that their service life is relatively long.—*February 16th*, 1940.

518,111. September 21st, 1938.—ELECTRIC FURNACES, Birmingham Electric Furnaces, Ltd., and Alfred Gordon Evans Robiette, both of Birlec Works, Tyburn Road, Erdington, Birmingham.

The object of the invention is to provide an improved furnace which will not only increase the life of the refractory material but will also enable it to be readily repaired. Referring to the drawing, the outer metal shell consists of two parts A of substantially hemispherical shape secured together, as by bolts through abutting flanges. The refractory lining for this shell

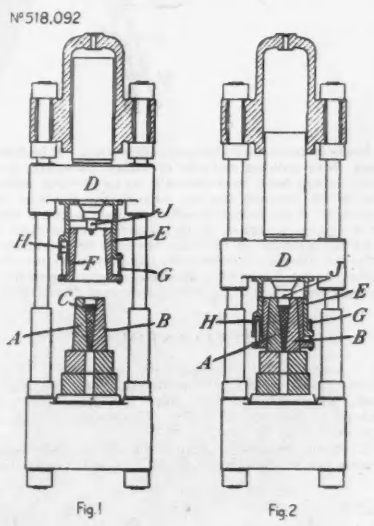


may consist of segmental bricks of substantially uniform shape secured to provide a spherical furnace chamber. Appropriate means may be combined with the shell to enable the furnace to be rocked or gyrated about a horizontal axis on suitable bearings or supports. The carbon electrodes B extend horizontally through bearings in the refractory lining disposed at opposite poles of the spherical member and are situated so that the arc formed between them is at the centre of the furnace, so as to be equidistant from all parts of the refractory lining. The furnace is formed with a charging aperture and a pouring spout.—*February 16th*, 1940.

MACHINE TOOLS AND SHOP APPLIANCES

518,092. August 15th, 1938.—LOCKING DEVICES FOR FORGING DIES, Loewy Engineering Company, Ltd., Ingersoll House, 9, Kingsway, London, W.C.2, Hugo Lorant, 46, Norrice Lea, London, N.2.

The accompanying drawings show a forging press, according to the invention, which is of a well-known type. On the base-plate is a two-part die, comprising the halves A and B, adapted to be moved apart from each other, by means not shown, for the insertion of a suitable blank C. Depending from a platen D is a barrel-shaped projection E in which the holder F for the die is housed. This holder has a conical bore which fits closely round the die. The holder is attached to the projection by means of bolts G with a certain play in the direction of the movement of the platen. Hydraulic cylinders H at the

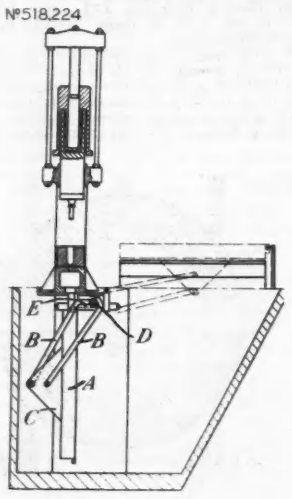


flanged end of the projection co-operate with pistons on the flanged end of the holder, so as to form a bolster between the holder and the platen. In operation before the press starts, its parts are all in the position shown in Fig. 1 with the platen raised and the holder being held in its lowermost position relatively to the projection through the heads on the bolts. A workpiece has been inserted into the die. When the platen descends, the tool J penetrates into the workpiece and performs a forging operation, thereby imparting to the workpiece a tendency to spread and cause the two halves of the die to come apart. According to the invention this separation is prevented by the holder F which, on the downward stroke of the platen, becomes seated with its conical inner surface on the outer surface of the die. At the same time the pistons enter into the cylinders H, and thereby set up a certain axial pressure which forces the

holder firmly on the die. When the forging operation is completed, the platen is raised, and the holder is lifted from the die by means of the bolts.—*February 16th*, 1940.

518,224. August 15th, 1938.—Improvements in Vertical Metal Extrusion Presses, Loewy Engineering Company, Ltd., Ingersoll House, 9, Kingsway, London, W.C.2., and Hugo Lorant, 46, Norrice Lea, London, N.2.

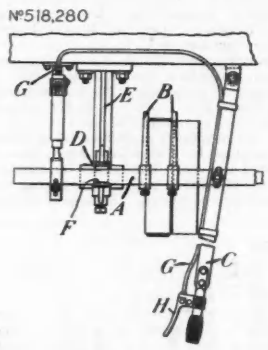
In most vertical extrusion presses no provision is made for receiving the extruded products when they emerge from the press and they drop into the pit below from which they have to be lifted out. According to this invention, a receiving device is provided in the pit of a press, so that the extruded products can drop into this receptacle. Means are provided for moving the receptacle outside of the pit and for lifting it into a position above floor level, so that it can easily be emptied. As shown in the drawing below, the press has a device for receiving the



extruded products which comprises an elongated receptacle A into which the products will drop from the press.. This receptacle is of sufficient length to take up the extruded product without deflecting it. Means for tilting the receptacle upwards to a position above floor level comprise pairs of links B attached to brackets C. On the pivot point of one of these pairs of links is a pinion D which is in engagement with a rack E, adapted to be moved in opposite directions by a hydraulic drive By this lever system the receptacle can be tilted upwardly into the horizontal position shown in chain lines. Means are provided by which one of the side walls of the receptacle is automatically opened for discharging purposes when it is in its top position.—*February 21st*, 1940.

518,280. August 20th, 1938.—Belt Shifting Devices, James Adie Dawes, 357, Warwick Road, Solihull, near Birmingham.

The belt shifting or striking gear may be of any suitable construction, and comprise, as shown, a sliding bar A carrying a pair of arms B, constituting a fork, for moving the belt between the two pulleys on an overhead counter-shaft. The bar is operated by a lever C. The bar slides through a rectangular aperture D in a hanger bracket E. The lower edge of the bar is formed with a notch or recess F for the purpose of locking it

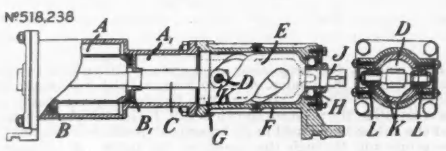


when it has been moved into the position shown. It is effectively prevented from moving endwise in either direction, and the belt cannot creep back inadvertently on to the fast pulley. A clearance is left between the top edge of the bar and the top of the aperture in the hanger bracket through which it slides, to enable the bar to be lifted up to bring the recess clear of the bottom of the aperture, so that the bar may be operated by the arm. For the purpose of raising the bar a remote control device is provided in the form of a Bowden wire G operated by a lever H upon the belt shifting arm.—*February 22nd*, 1940.

MISCELLANEOUS

518,238. August 19th, 1938.—Reciprocating Engines, Albert Frank Collins, "Patterdale," 51, Barnett Wood Road, Ashstead, Surrey, and the London Passenger Transport Board, 55, The Broadway, Westminster, London, S.W.1.

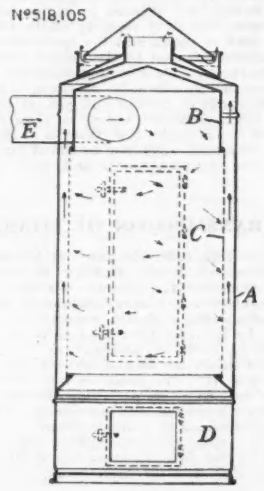
The invention relates to improvements in door operating mechanisms, particularly those of vehicles and to pneumatic or



hydraulic door engines. Referring to the drawings, a differential pressure door engine comprises large and small cylinders A and A_1 in which pistons B and B_1 operate, the pistons having a common piston rod C. The pistons move in either direction by control of suitable compressed air supply and exhaust valves not shown. At the end of the piston rod is a transverse spindle D. The spindle passes through two helical slots in a rotary sleeve E which is supported for rotation in a coaxial extension F of the cylinder A, by means of end bearings G H of which the latter supports an extension J of the sleeve E forming an engine arm spindle, to which the arm which operates a door is secured. The spindle D carries a pair of rollers K which engage in the slots. Outside the rollers the spindle carries a further pair of rollers L which engage in diametrically opposite parallel longitudinal guide slots. The helical slots each extend only half-way round the sleeve and in each case the half pitch of the helix is equal to the stroke of the pistons. It will be seen that the spindle D cannot rotate about the axis of the piston rod but can only move in a straight line owing to the rollers K engaging in the longitudinal guides. Consequently as the piston rod is moved through a complete stroke in one direction or the other, the sleeve E and therefore the door arm spindle will be rotated through 180 deg. to open or close the door.—*February 21st*, 1940.

518,105. September 17th, 1938.—Dust Extracting and Collecting Apparatus, Richard Baker Lister, Wallace Paull Lister, and John Paull Lister, trading in co-partnership as James Lister and Sons, of 141, High Street, West Bromwich, and 16, Owen Street, Tipton.

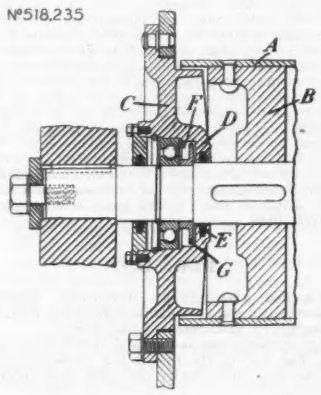
A sheet-metal casing A has a conical top and a short outlet pipe upstanding centrally therefrom. Within the upper part of the casing is a cylindrical hood B. The open lower rim of the hood is outwardly flanged to provide support for a canvas or other filter C of open sleeve formation secured by a coiled spring ring. The filter sleeve is attached by means of a ring



at its lower end to the outwardly flanged upper rim of an upwardly tapering conical ring secured to the interior wall of the casing adjacent to its lower end, the space within and beneath this conical ring constituting a dust box D within the base of the casing. An inlet pipe E passes horizontally through the casing into tangential communication with the interior of the hood, the arrangement being such that on air and dust being admitted a cyclonic settling and filtering action is set up within the apparatus, thereby causing the dust to settle into the dust box, and the filtered air to be passed upwards from the filter sleeve and within the casing to the air outlet pipe at the top.—*February 16th*, 1940.

518,235. August 18th, 1938.—Housing for Ball and Roller Bearings, Charles Crofton and Co. (Engineers), Ltd., Church Bank Offices, Wallsend-on-Tyne, Northumberland, and Reginald William Mann, 62, Monkseaton Drive, Monkseaton, Northumberland.

Referring to the accompanying drawing, the roller A of a belt conveyor is supported on end plates B keyed to a shaft which is carried in ball bearings housed in a casting C secured to the side plate of the conveyor. The casting has a flange D which fits around the shaft with small clearance and it is formed with a groove E in which is a dirt-excluding felt ring. The housing for the ball bearing is so shaped as to provide a space F for



grease between the bearing and the flange. A disc G surrounds the shaft and extends nearly to the outer periphery of the space F close to the flange D. This ring has a boss portion as shown, and it is interposed between the inner race of the bearing and a shoulder on the shaft against which it is held by means of a spring ring fitting in a circumferential groove in the shaft. Any dirt or grit that may find its way past the ring in E will not be able to mix with the grease in the space F until it has travelled radially round the disc and along its outer edge. As it would take a very long time to do so, the effective life of the dirt excluding means as a whole is prolonged by the presence of the disc.—*February 21st*, 1940.

PERSONAL AND BUSINESS ANNOUNCEMENTS

Dewrance and Co., Ltd., announce that Mr. W. G. Suffield has been appointed a Director of the company, and that he will continue to control sales, as formerly. The company also states that Mr. A. Denison Ross, M.A., A.M.I. Mech. E. has been appointed technical assistant to the management.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institute of Fuel

Thursday, April 25th.—Connaught Rooms, Great Queen Street, W.C.2. "Some Food for Thought in Steam Plant Design," J. N. Dundas Heenan. 6 p.m.

Institute of Metals

Wednesday, May 8th.—Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. General Meeting. 2 p.m. May Lecture, "The Cyclotron and its Applications," J. D. Cockroft. 7 p.m.

Institution of Automobile Engineers

Tuesday, April 23rd.—Birmingham Centre. James Watt Memorial Institute, Great Charles Street, Birmingham. "Some Problems We Meet," L. H. Dawtrey. 7 p.m.

Institution of Chemical Engineers

Tuesday, April 23rd.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "A Review of Certain Unit Processes," J. C. Farrant. 5.15 p.m.

Institution of Civil Engineers

To-day, April 19th.—Savoy Hotel, London, W.C.2. Luncheon. 12.45 p.m. for 1.15 p.m.

Tuesday, April 23rd.—Great George Street, Westminster, S.W.1. "The Remodelling of the Assiut Barrage, Egypt," J. E. Bostock. 5.30 p.m

Tuesday, May 7th.—Great George Street, Westminster, S.W.1. "Cliff-Stabilisation Works in London Clay," J. Duvivier. 5.30 p.m.

Institution of Electrical Engineers

To-day, April 19th.—Transmission Section. Waldorf Hotel, Aldwych, W.C.2. Dinner. 7 for 7.15 p.m.

Tuesday, April 23rd.—Wireless Section. Savoy Place, Victoria Embankment, W.C.2. "War-Time Standardisation," P. R. Coursey. 6 p.m. Scottish Centre. Royal Technical College, George Street, Glasgow. "The Trolleybus," G. F. Sinclair. 6.30 p.m.

Thursday, April 25th.—Savoy Place, Victoria Embankment, W.C.2. "Thermodynamics and the Coldest Temperatures," C. G. Darwin. 6 p.m.

Wednesday, May 1st.—Wireless Section. Savoy Place, Victoria Embankment, W.C.2. "Civil Air Transport Communication," A. D. Hodgson. 6 p.m.

Friday, May 3rd.—Meter and Instrument Section. Savoy Place, Victoria Embankment, W.C.2. "Insulation," H. Warren. 6 p.m.

Wednesday, May 8th.—Savoy Place, Victoria Embankment, W.C.2. "Mechanical Integrity in the Design of Electrical Circuit-Breakers," M. C. Hunter. 6 p.m.

Institution of Engineers-in-Charge

To-day, April 19th.—Holborn Restaurant, London, W.C.1. Annual Dinner. 6 for 6.30 p.m.

Institution of Mechanical Engineers

To-day, April 19th.—Storey's Gate, Westminster, S.W.1. "The Problems of the Singing Propeller," W. Kerr, J. F. Shannon, and R. N. Arnold. 6 p.m.

Friday, April 26th.—Engine Group. Storey's Gate, Westminster, S.W.1. "Fuel Injection in Oil Engines in Relation to Combustion," G. W. A. Green. 6 p.m.

Friday, May 3rd.—Engine Group. Storey's Gate, Westminster, S.W.1. "Operating Experience with Gas Producers." 6.30 p.m.

Institution of Structural Engineers

Tuesday, April 23rd.—Yorkshire Branch. Hotel Metropole, Leeds. "New Developments in Pre-stressed Concrete Construction," T. J. Gueritte. 7 p.m.

Iron and Steel Institute

Thursday and Friday, May 2nd and 3rd.—4, Grosvenor Gardens, S.W.1. Annual Meeting. 10 a.m. each day. For programme, see page 357.

Junior Institution of Engineers

Saturday, April 20th.—Monico Restaurant, Piccadilly, W.1. Annual Luncheon. 1 for 1.30 p.m.

Friday, April 26th.—39, Victoria Street, S.W.1. "The Construction of High Level Huts in the Alps," R. P. Mears. 6.30 p.m.

Old Centralians

Wednesday, April 24th.—Institution of Mechanical Engineers, Storey's Gate, S.W.1. Annual General Meeting. 5.30 p.m.

Newcomen Society

Wednesday, April 24th.—Science Museum, South Kensington, S.W.7. "The Earliest Industrial Use of Coal," T. T. Read and "A Picardy Post Mill, 1630," Enid and Rex Wailes. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, April 19th.—Mining Institute, Newcastle-upon-Tyne. "Modern Joiner's Work and Woodworking Tools," A. C. Meredith, and "Decorative Veneers," L. C. W. Jenkins. 6 p.m.

Wednesday, April 24th.—Student Section. Bolbec Hall, Newcastle-upon-Tyne. "Hatchways," J. B. Davies. 6.45 p.m.

Sheffield Metallurgical Association

Tuesday, April 23rd.—198, West Street, Sheffield, 1. "Quenching," G. Parkin. 6.30 p.m.

Royal Institution of Great Britain

Friday, April 26th.—21, Albemarle Street, W.1. "Geophysical Study of Submarine Geology," E. C. Bullard. 9 p.m.

CATALOGUES

Hadfields, Ltd., Sheffield.—Catalogues No. 438, "Era" non-corroding steels; No. 439, lubrication of jaw crushers; and No. 440, manganese steel railway track.

British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. Details of the new "Mazda" 80 watt 200/250 volt fluorescent lamp and the necessary control units and reflector equipment.

Robert Boby, Ltd., Bury St. Edmunds. A folder illustrating the wide range of steel buildings and constructional work in which the firm specialises and a number of the machines it makes, particularly in connection with malting.